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WATER QUALITY SURVEY
OF THE
LOWER STURGEON RIVER
NIPISSING DISTRICT

JUNE - AUGUST 1977

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WATER QUALITY SURVEY

of the

LOWER STURGEON RIVER

NIPISSING DISTRICT

JUNE - AUGUST 1977

NORTHEASTERN REGION

TECHNICAL SUPPORT

and

LABORATORY SERVICES BRANCH

MICROBIOLOGY SECTION

1979

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ACKNOWLEDGEMENTS

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The authors, G. S. Hendry, S. Janhurst and G. Myslik, wish to acknowledge the contributions of the study participants in the collection of samples, enumeration of bacteriological parameters, preparation of figures and tables, reviews of the draft reports and finally the typing to the manuscript.

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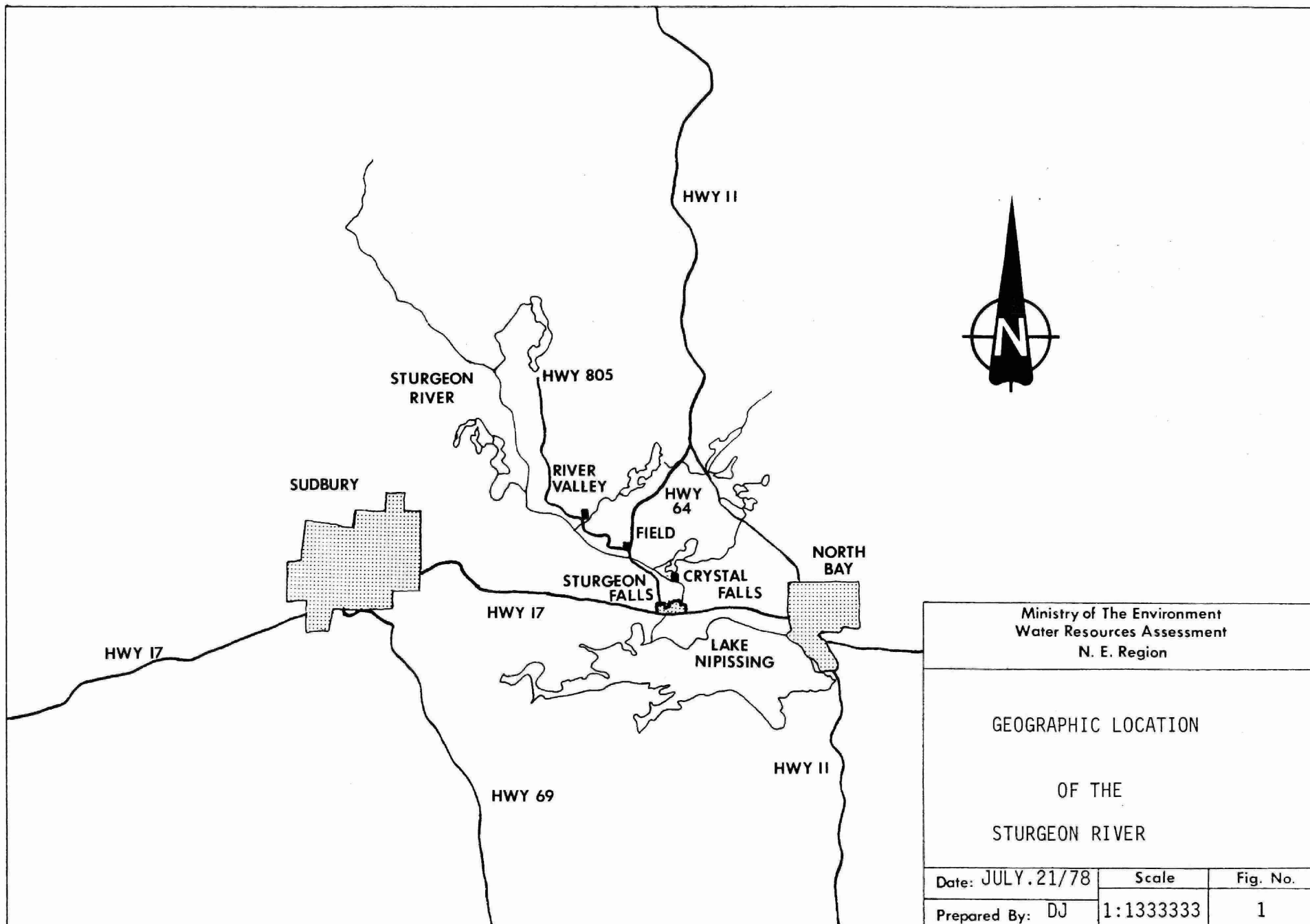
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The Sturgeon River is located in Northeastern Ontario, (Figure 1). It originates approximately 104 km north of the City of Sudbury and flows 160 km through dense forested Precambrian terrain which varies in character from low and swampy to rugged. Before it empties to Lake Nipissing, the Sturgeon River drains a watershed of 6656 km².

There are a number of communities situated along the Sturgeon River. The northern most is River Valley (population 227) 16 km north of Field along Hwy 805. Field has a population of 655 and is located at the junction of Hwys. 64 and 805, while the Hamlet of Crystal Falls, population 81, is situated 20 km south of Field. The largest population centre (6500) is the Town of Sturgeon Falls which is bisected by Hwy. 17 and is approximately 10 km from the mouth of the river.

Hydro-electric generating facilities are located near Crystal Falls but, industrial activity on the Sturgeon River is primarily related to the forest industry. Log storage and soaking operations are carried on in the river at Field while the Abitibi Forest Products Mill in Sturgeon Falls produces hardboard and corrugated products from wood chips. There are two known significant waste discharges to the river: the process waste from the Abitibi Mill, and the combined domestic wastes from the Abitibi Mill and the Town of Sturgeon Falls which are directed to an activated sludge process sewage treatment plant. The treated wastes are discharged to the Sturgeon River approximately 2 km downstream of the Abitibi Mill.



Ministry of The Environment Water Resources Assessment N. E. Region		
GEOGRAPHIC LOCATION OF THE STURGEON RIVER		
Date: JULY.21/78	Scale	Fig. No.
Prepared By: DJ	1:1333333	1

Numerous lodges, marinas, trailer parks and cottages catering to Lake Nipissing sport fishermen and local residents have become established along the river downstream from the Mill and sewage treatment plant outfalls.

The lower Sturgeon River below the Abitibi Forest Products Mill was considered in the past to be a major spawning area for yellow pickerel (walleye) which form the basis of the Lake Nipissing sport fishery.

The lower stretch of the river also functions as a spawning ground for white bass, and in the past has served the same purpose for lake sturgeon.

INTRODUCTION

There is a history of water quality problems on the lower Sturgeon River downstream of Sturgeon Falls. In previous investigations, these problems have been expressed as:

- extensive deposits of wood chips and fiber in river sediments
- reduction of water clarity (turbidity)
- the bubbling of gas, likely methane, from the sediments to the surface of the river
- algae blooms and bacterial contamination
- the profuse growth of slimes (sewage fungus)
- the degradation of the biological environment resulting in a reduction of the variety and numbers of sediment dwelling organisms.

The deteriorated water quality on the lower Sturgeon River had been associated with the operation of the Abitibi Forest Products Mill and the discharge of untreated sewage by the Town of Sturgeon Falls.

Construction of an activated sludge sewage treatment plant in 1973 and the adoption of a pollution abatement program by the Abitibi Mill was expected to alleviate some of the problems. However, operational difficulties with the process waste treatment facilities at the Mill resulted in lengthy delays in bringing the pollution abatement system on stream.

During the winter of 1976, concern over the state of water quality in the lower Sturgeon River with regard to slimes, suspended particles, bacterial contamination and the suitability

of the river for recreational and domestic use, prompted a request for an environmental quality survey during the summer of 1977.

At the same time, recognition by the Ministry of the Environment that unacceptable conditions existed in the Sturgeon River as a result of wastewater discharges from the Mill led to the formulation of a "Control Order" which was issued on November 3, 1977. Abitibi Forest Products Limited was directed to implement programs leading to the installation and operation of abatement facilities to affect the following:

1. To reduce the suspended solids concentration in the mill wastewater discharges to 50 milligrams per litre or less on a monthly average by December 31, 1981.
2. To reduce the phenol loading from the press section of the hardboard mill to a maximum of 8.5 lbs per day by December 31, 1981.
3. To control the discharge of BOD₅ in mill wastewaters by December 31, 1982, so that the levels of dissolved oxygen in the river are maximized for various flow rates and temperatures.

This report presents the results of the field survey conducted during the summer of 1977. Report organization is standard and presentation is under the following headings: Purpose and Study Methods, Results, Discussion and Conclusions.

The field and laboratory methodologies employed were according to standard techniques and are described briefly. The results section is a statement of observations made by the sampling crew and a presentation of field and laboratory findings.

The rationale for the investigation of chemical, physical and biological parameters and explanations of the significance of the results obtained are found in the discussion.

Conclusions and recommendations are based on survey results.

Because the survey was designed to evaluate the water quality condition of the river, the specifics of the Abitibi Forest Products Mill operation, processes, effluent composition and origin are not discussed. Information pertinent to the operation of the Mill and Mill effluents is available from the Industrial Abatement Section, North Bay District Office of the Ministry of the Environment.

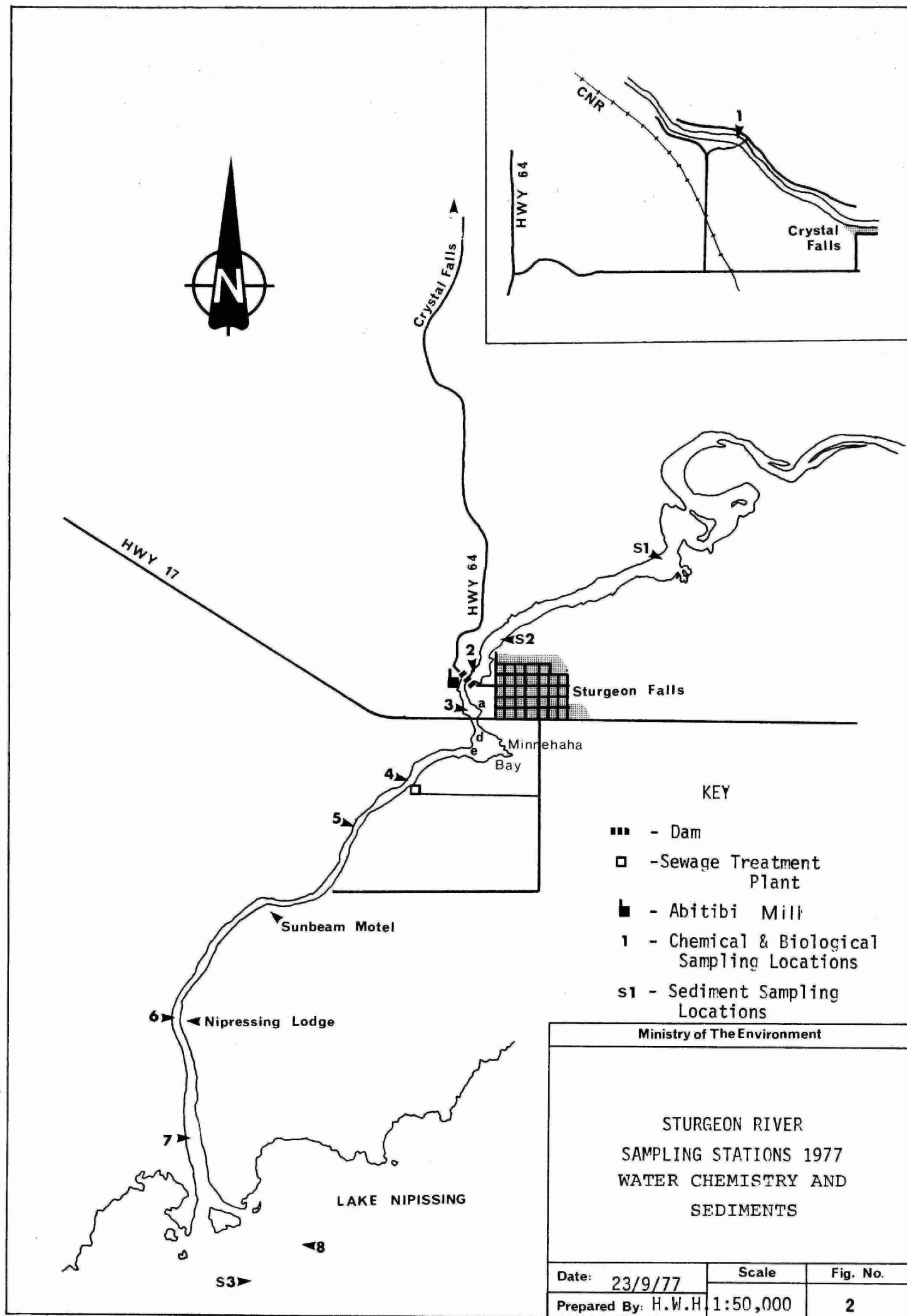
PURPOSE AND STUDY METHODS

The purpose of the survey was to investigate the status of water quality in the Sturgeon River downstream of Sturgeon Falls and Abitibi Forest Products Limited. The survey was designed to evaluate water quality as it was perceived aesthetically and as it was expressed by the presence and quantities of specific chemical, bacterial and biological parameters. Three study components were involved:

1. Aesthetics and Chemical Water Quality
2. Bacteriological Water Quality
3. Sediment Composition and Invertebrate Presence

1. Aesthetics and Chemical Water Quality

The general appearance of the study area was recorded and photographs were taken of conditions that were considered to be indicative of environmental degradation. Chemical water quality was evaluated from composite samples (0 to 5 metres deep) taken at eight (8) stations upstream and downstream of Sturgeon Falls. Sampling locations are shown in Figure 2. Chemical analyses were performed at the Ministry of the Environment Laboratory in Toronto. Water samples for chemical analysis were collected June 24, 26, 28 and August 9 and 12. The samples obtained Sunday, June 26 were taken at a time when reduced Mill discharges were observed.



The following groups of chemical parameters were monitored.

a) Characterization Group

Hardness	Sodium
Alkalinity	Potassium
Conductivity	Chloride
pH	Sulphate
Colour	
Calcium	
Magnesium	

b) Nutrient Group

Ammonia	Nitrate
Total Kjeldahl Nitrogen	Total Phosphorus
Nitrite	Inorganic Carbon

c) Metals Group

Copper	Cadmium
Nickel	Arsenic
Lead	Iron
Zinc	Manganese

d) Industrial Group

Biochemical Oxygen Demand (BOD)	Tannins and Lignins
Chemical Oxygen Demand (COD)	Total Organic Carbon
Suspended Solids	Solvent Extractables
Dissolved Solids	Petroleum Hydrocarbons
Phenols	

In addition, measurements of water temperature, dissolved oxygen concentration and water clarity were obtained at each sampling station. A model 54 Y.S.I. meter was used to measure oxygen and temperature. Water clarity was determined with a Secchi disc. Chlorophyll a samples were obtained through the photic zone and were submitted to the laboratory for analysis.

2. Bacteriological Water Quality

Bacteriological water quality was investigated during two five-day surveys carried out between June 25 and 29,

and August 10 and 14. Daily samples were taken one metre below the river surface as well as directly from piped effluents. In total, forty (40) stations; twenty eight (28) shoreline and twelve (12) mid-river, were monitored (Figure 3).

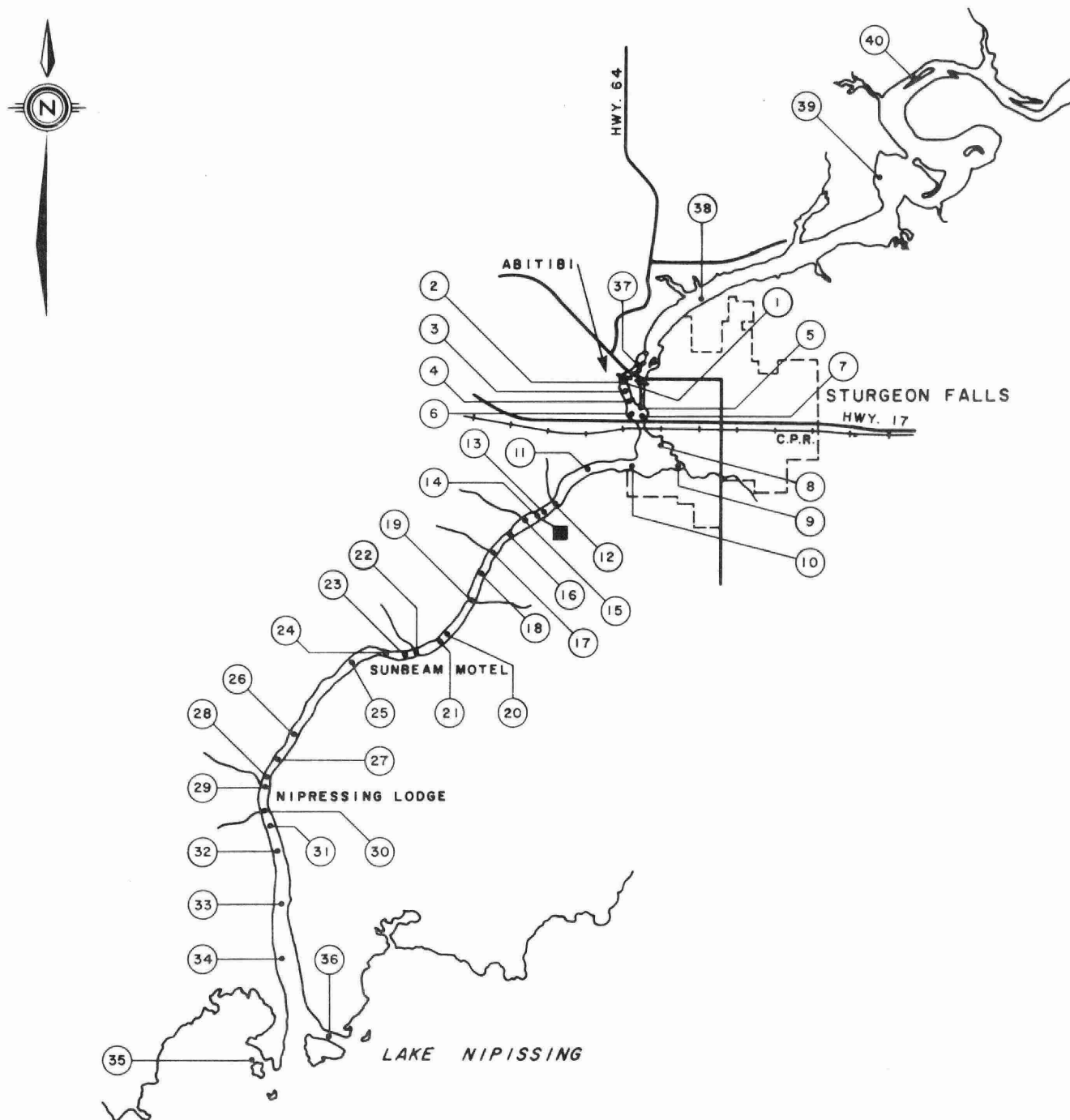
Total coliform, fecal coliform and fecal streptococcus bacteria were enumerated on-site in a mobile laboratory situated at the Sturgeon Falls sewage treatment plant. The density of heterotrophic bacteria and the opportunistic pathogen Pseudomonas aeruginosa was also obtained. The heterotrophic bacteria density was determined from 5 sampling locations, two of which were located upstream (Stations 37 and 40) and three downstream (Stations 6, 20, and 28), (Figure 3).

The following methodologies were used for bacterial enumeration:

1. Total coliform (TC) bacteria was determined as a count of dark-red colonies with gold metallic sheen grown on a membrane filter (Gelman GN6) with m-Endo LES agar (M.O.E. 1976).
2. Fecal coliform (FC) bacteria were determined as a count of acid producing yellow to yellowish-green colonies grown on a membrane filter with MacConkey broth at 44.5°C (M.O.E. 1976).
3. Fecal streptococcus (FS) bacteria were obtained from a count of pink or red colonies grown on a membrane filter with m-Enterococcus agar (M.O.E. 1976).

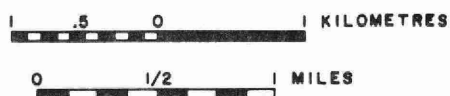
FIGURE 3 - LOCATION OF BACTERIOLOGICAL SAMPLING STATIONS ON THE STURGEON RIVER.

14



LEGEND

- DAM
- SEWAGE TREATMENT PLANT
- FLOATING LOG-CHAIN BARRIER
- SAMPLING STATION



MINISTRY OF THE ENVIRONMENT

RECREATIONAL LAKES PROGRAM

STURGEON RIVER

1977 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: A.R.S.

DATE: FEB., 1978

CHECKED BY:

DRAWING NO: 7996

4. Pseudomonas aeruginosa (PA) were determined as a count of flat, tan to brown colonies grown on a membrane filter with mPA medium (Levin and Cabelli, 1972).
5. Heterotrophic bacteria (HB) were obtained from a total count of colonies from surface inoculated plates of modified Foot and Taylor medium, incubated for seven days at 20°C (Hendry, 1977).

Fecal coliforms were identified using the Enterotube system (Hoffmann-LaRoche). In this manner, Klebsiella pneumoniae was identified from the fecal coliforms.

Pseudomonas aeruginosa was identified by its action upon skim milk and acetamide agars, along with the oxidase test.

3. Sediment Composition and Invertebrate Presence

Sediment composition was investigated by means of dredge samples taken at locations shown in Figure 2 including Stations 3a, d, e, and 4 through 8. The terms of reference for sediment evaluation were:

- (1) organic vs inorganic composition
- (2) twig or bark debris presence
- (3) fiber content
- (4) presence and numbers of aquatic organisms
- (5) presence of sludge, slime or algae.

Sediment surveys were performed during both sampling periods in June and August. Three 9" x 9" Ponar dredge grabs were taken at each station; within 5 metres of each river bank and one in the middle of the river channel.

Sampling upstream of Abitibi Forest Products was undertaken during the August sampling period only. A 6" x 6" Ekman dredge was used to obtain sediments.

During the August sediment survey, macroinvertebrates inhabiting the sediments were identified and enumerated to facilitate the calculation of diversity indices used in the evaluation of habitat quality for aquatic life.

RESULTS

1. Aesthetics and Chemical Water Quality

Aesthetic Perception

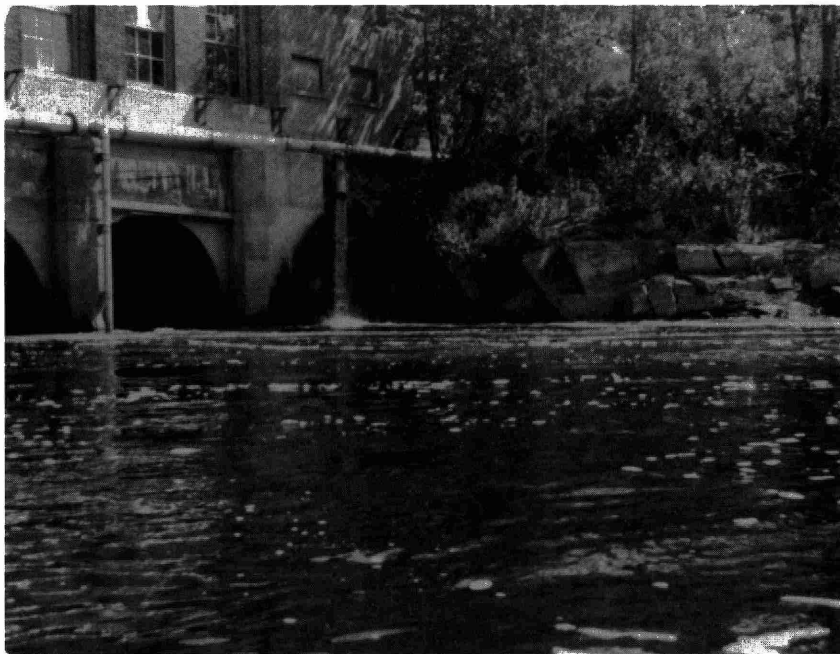
a) June 24 to 29

During the first survey period, the aesthetic condition of the Sturgeon River at most sampling locations appeared generally good except for the area directly below the Abitibi Mill. Here, effluent discharges had a visible effect on river appearance.

The main Abitibi Forest Products effluents which had a visible effect on the aesthetic appearance of the Sturgeon River, were located on both sides of the Mill tail race. On the east side, a warm, cloudy, light brown coloured discharge spilled from an elevated pipe (Plate 1). Slimy growths were observed on submerged rocks directly below this outfall. The current carried a turbidity cloud along the east bank. This cloud dissipated approximately 20 m downstream following dilution by flow from the Sturgeon River dam.

On the west side of the Mill tail race, a cloudy, brown effluent was discharged to the river below the surface of the water (Plate 2). Again, a turbidity cloud was carried downstream along the west river bank for a distance of 50 to 70 m.

In the mixing area downstream of the two cloudy discharges, particles of wood fiber were seen suspended by the upwelling currents.

PLATE 1

East side of Abitibi Forest Products tail race.
Brown discharge spills from elevated pipe and forms
a turbidity cloud along east shore.

PLATE 2

Cloudy, turbid, foaming effluent released below the
river surface on west side of tail race.

At sampling Station 3A, Figure 2, a backwater bay downstream of the Mill tail race, gas bubbles were constantly rising and breaking at the surface (Plate 3). A lighted match held over the bubbles flashed, indicating the release of flammable gases.

Out from this bay, on the edge of the fast flowing river, suspended wood fiber particles were still seen.

Downstream of the Highway 17 bridge no visible conditions denoting environmental degradation were apparent. However, the water seemed to be less clear than at sampling locations upstream of the Mill.

As observed by the sampling crew, yellow perch, walleye, smallmouth bass and northern pike were being caught by anglers the full length of the river downstream of Abitibi Forest Products. Large numbers of walleye were being caught in front of the Sunbeam Motel.

August 9 to 14

Although the upstream reaches of the Sturgeon River appeared aesthetically pleasing during the second survey period, downstream of the Abitibi outfalls the river looked very turbid and had a stale fishy odour. Turbidity clouds caused by Mill discharges were observed on both sides of the tail race. Submerged rocks, for a distance of 25 metres downstream of the effluent pipe on the east side, were covered with a rusty fluffy slime deposit (Plate 4). Newer, white growths of the fluffy slime were found on a wooden maintenance raft

PLATE 3

Gas bubbles rising and breaking on the surface in stagnant Bay (Station 3A) on east side of the Sturgeon River.

PLATE 4

Deposits of decaying sewage fungus slime covering submerged rocks below the elevated pipe discharge on the east side of the tail race (Plate 1).

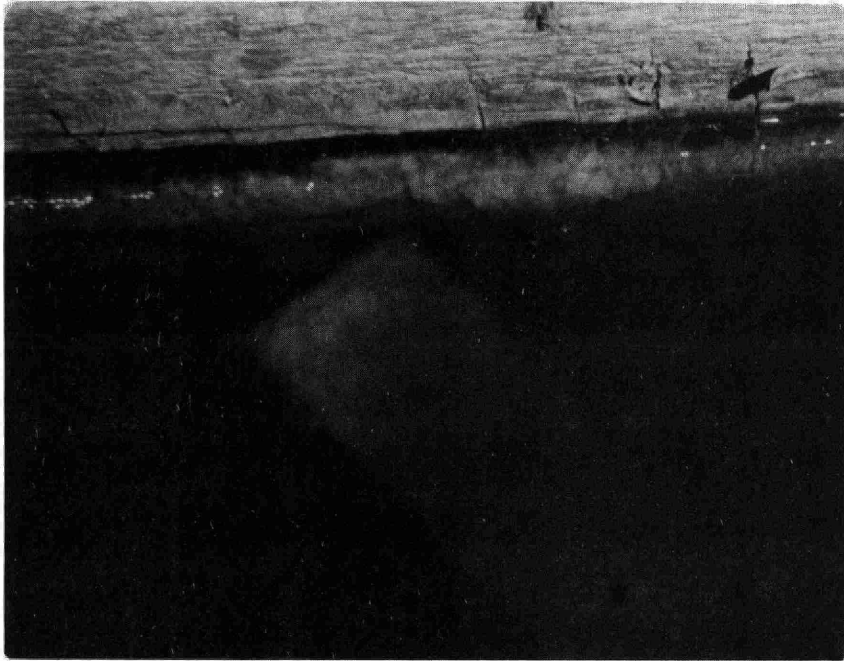
situated just downstream of the subsurface outfall on the west side of the tail race (Plate 5). The upwelling and flow of water in the Mill tail race was causing the slimy growths to break away from their substrate and to be carried downstream by the current (Plate 6).

At sampling station 3 (Figure 2) on the edge of the fast water and the bay, many detached amorphous white slime masses, some as long as 10 cm. were seen suspended in the current among the particles of wood fiber. The fluffy slime masses in the fast water were visible down to the Highway 17 bridge.

Although no suspended material was observed downstream of the bridge, the Sturgeon River was not particularly inviting for water-based activity (except fishing) due to turbidity and a stale fishy odour. Even so, small groups of swimmers and bathers were seen during the second survey at various downstream locations.

Except for narrow bands of aquatic vegetation growing parallel to the Sturgeon River shores, there was no evidence of excessive vegetative growth in the River. However, very dense plant growth occurred at the mouth of the river extending well into Lake Nipissing and along the shoreline of the lake.

Anglers and unidentified species of fish were observed in the Sturgeon River right up to the Mill outfalls; but, the quality and productivity of the sport fishery appeared to be substantially reduced since the June sampling period. Few walleye were being caught.

PLATE 5

Fluffy, cotton-wool-like growths of slime on wooden rafts just downstream of discharge shown in Plate 2.

PLATE 6

Suspension of slime particles by upwelling currents. The broken away pieces of slime were observed below the Milloutfalls down to the Highway 17 bridge.



Water Chemistry

Results of chemical analyses performed for water samples collected during regular Mill discharge days June 24, 28; August 9 and 12 were summarized. Mean values and ranges are shown in Table 1.

Within the characterization parameter group, increases in conductivity, colour, sodium and a slight decline in pH were observed downstream of the Abitibi outfalls. Other parameters in this group exhibited fairly uniform upstream and downstream concentrations.

In the nutrient group, ammonia and nitrate concentrations declined at stations 3 to 8 downstream of the Mill, while total Kjeldahl nitrogen and phosphorus concentrations increased.

Within the metals group, only the manganese concentrations were seen to increase below the Mill discharges.

The industrial group of chemical parameters showed greater differences between upstream and downstream locations than did the other groups. Increased concentrations of BOD, COD, suspended and dissolved solids, tannins and lignins, organic carbon and phenols were found in the downstream samples. Petroleum hydrocarbons were undetectable at all times, while concentrations of solvent extractables remained uniformly low.

TABLE 1

CHEMICAL WATER QUALITY OF THE LOWER STURGEON RIVER 1977

<u>CHARACTERIZATION</u>		<u>STATION</u>							
<u>PARAMETERS</u>		1	2	3	4	5	6	7	8
HARDNESS	MEAN	29	29	29	29	29	29	29	32
	RANGE	27-30	27-30	27-31	28-30	27-30	27-30	28-30	28-40
ALKALINITY	M	18	18	19	21	21	21	21	23
	R	17-18	17-19	18-20	20-21	20-22	20-22	20-22	20-29
CONDUCTIVITY	M	72	73	81	83	84	85	84	87
	R	70-74	70-76	73-84	79-84	83-86	84-86	83-85	81-96
pH	M	7.55	7.22	7.20	6.95	6.86	6.84	6.82	6.99
	R	6.88-8.55	6.95-7.43	6.57-7.84	6.75-7.23	6.69-7.16	6.61-7.17	6.50-7.20	6.90-7.33
COLOUR	M	20	30	40	40	45	40	40	35
	R	15-30	20-40	20-50	20-60	30-70	30-60	30-60	15-70
CALCIUM	M	7.9	7.9	8.1	8.1	7.9	7.9	8.1	8.7
	R	7.5-8.6	7.5-8.2	7.5-8.8	8.0-8.2	7.5-8.2	7.5-8.2	7.8-8.4	8.0-10.4
MAGNESIUM	M	2.1	2.2	2.2	2.2	2.2	2.2	2.2	2.6
	R	2.0-2.5	2.0-2.2	2.0-2.3	2.0-2.3	2.0-2.4	2.0-2.3	2.0-2.3	2.0- 3.5
SODIUM	M	1.2	1.1	2.7	3.5	4.0	3.9	3.7	3.3
	R	0.9-1.3	0.9-1.3	1.4-3.6	2.6-3.7	3.8-4.2	3.5-4.4	3.2-4.3	2.0-5.1
POTASSIUM	M	.55	.55	.58	.63	.65	.65	.65	.68
	R	-	-	-	-	-	-	-	-
CHLORIDE	M	.88	.88	1.2	1.2	1.3	1.3	1.4	1.7
	R	.70-1.0	.80-.90	.90-1.5	1.1-1.4	1.1-1.3	1.1-1.4	1.2-1.5	1.3-2.1
SULPHATE	M	14.1	14.3	14.8	15.3	15.6	15	15.5	14.6
	R	13.5-15	13-15	14-16	14.5-16.5	14.5-16.5	14.5-15.5	14-16.5	13-16.5

TABLE 1

		STATION							
<u>NUTRIENTS</u>		1	2	3	4	5	6	7	8
AMMONIA	MEAN	.016	.017	.004	.003	.003	.002	.006	.010
	RANGE	.014-.018	.008-.022	.002-.006	.002-.004	.002-.006	-	.002-.008	.002-.026
TOTAL KJELDAHL M		.31	.31	.37	.40	.38	.41	.37	.41
NITROGEN	R	.24-.44	.28-.36	.34-.40	.36-.48	.36-.42	.30-.48	.32-.48	.31-.48
NITRITE	M	.002	.002	.003	.003	.003	.003	.002	.002
	R	.001-.002	.001-.003	.001-.004	.002-.003	.002-.003	.002-.003	.002-.003	.002-.003
NITRATE	M	.015	.017	.005	.005	.006	.006	.006	.006
	R	.008-.019	.005-.024	.005-.006	-	.005-.007	.005-.008	.005-.008	.005-.007
TOTAL PHOSPHORUS	M	.012	.011	.021	.019	.019	.028	.015	.015
	R	.008-.016	.008-.014	.008-.028	.004-.024	.008-.026	.008-.053	.010-.018	.008-.024
INORGANIC CARBON	M	5	4	5	5	6	6	6	6
	R	3-6	3-6	3-7	3-7	3-7	4-7	4-7	4-7
<u>METALS</u>									
COPPER	M	.02	.02	.04	.04	.03	.03	.04	.03
NICKEL	M	.02	.02	.02	.02	.02	.02	.02	.02
LEAD	M	.02	.02	.02	.02	.02	.02	.02	.02
ZINC	M	.02	.02	.02	.02	.02	.02	.02	.02
CADMIUM	M	.01	.01	.01	.01	.01	.01	.01	.01
ARSENIC	M	.001	.001	.001	.001	.001	.001	.001	.001
IRON	M	.15	.18	.20	.20	.20	.19	.21	.16
	R	.10-.20	.14-.21	.15-.25	.14-.25	.14-.24	.14-.26	.14-.26	.08-.31
MANGANESE	M	.033	.036	.046	.047	.051	.048	.051	.038
	R	.024-.043	.032-.044	.041-.055	.042-.056	.044-.067	.042-.056	.044-.063	.012-.063

		STATION							
		1	2	3	4	5	6	7	8
<u>INDUSTRIAL</u>									
<u>GROUP</u>									
B.O.D.	MEAN	.60	.85	2.7	3.7	4.5	3.6	3.1	2.9
	RANGE	.40-.80	.50-1.6	1.6-4.0	1.8-6.0	2.0-8.5	2.0-6.0	1.6-5.5	.50-8.0
C.O.D.	M	22	25	55	59	55	51	52	41
	R	10-35	18-28	36-74	48-80	48-63	47-59	42-67	25-63
SUSPENDED SOLIDS	M	2.9	2.7	5.6	6.9	5.1	4.0	4.5	3.2
	R	2.4-3.9	2.0-4.3	3.9-6.8	4.8-12	4.9-5.2	3.6-4.7	4.0-5.0	1.5-5.0
DISSOLVED SOLIDS	M	48	48	53	54	55	55	55	56
	R	46-49	46-49	49-55	52-55	-	-	-	52-56
PHENOLS ug/l	M	1.5	1.5	27	26	29	30	23	12
	R	1-3	1-2	13-45	22-31	25-37	22-35	21-25	3-35
TANNINS & LIGNINS	M	.7	.7	2.8	4.2	4.5	4.7	5	4.2
	R	.5-1.0	.5-1.0	1.5-4.0	3.5-5.0	3.5-6.0	4.0-6.0	4.0-7.0	1.5-8.0
ORGANIC CARBON	M	6	7	13	14	17	17	15	12
	R	5-6	5-12	11-15	7-18	13-21	13-20	12-19	7-22
SOLVENT EXTRACTABLES	M	1	1.3	1.3	1.3	1	.7	1	1
	R	-	-	-	-	-	-	-	-
PETROLEUM HYDROCARBONS	M	NON	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
	R	DETECTABLE	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

* Concentrations in mg/L except conductivity (umhos/cm), pH, colour (Hazen units) and phenols (ug/L).

* N.D. - Non-Detectable

Chemical analyses of water samples obtained Sunday, June 26, during a period of reduced effluent discharge are summarized in Table 2. For comparison, only those parameters which exhibited changes from upstream concentrations during regular Mill discharge days are included in the table.

As shown in Table 2, differences between upstream and downstream water chemistry were not as apparent as during periods of regular discharge. Although a slight decline in pH was noticed in the downstream stations, concentrations of other parameters were not appreciably different from upstream values.

Samples taken at station 8 in Lake Nipissing June 26, contained higher concentrations of sodium, manganese, dissolved solids, phenols and organic carbon than found in the lower reaches of the river.

Dissolved oxygen and temperature profiles are shown in Figure A 1 to 5; in the Appendix and, for ease of interpretation, dissolved oxygen readings taken 2 metres from the bottom at each sampling location are summarized in Table 3.

A pattern of diminishing oxygen concentration downstream of Abitibi Forest Products was observed on all sampling days. On August 9, extremely low concentrations of oxygen were measured at station 8 in Lake Nipissing.

Water temperatures during the June sampling period were approximately 19°C and during August they approached 21°C.

TABLE 2

CHEMICAL WATER QUALITY, LOWER STURGEON RIVER
SUNDAY, June 26, 1977 SELECTED PARAMETERS

<u>CHARACTERIZATION</u>	<u>STATION</u>							
<u>GROUP</u>	1	2	3	4	5	6	7	8
CONDUCTIVITY	68	73	74	73	74	75	76	84
pH	7.27	7.29	7.12	7.23	7.04	7.04	7.00	6.93
COLOUR	20	20	20	20	20	20	20	20
SODIUM	1.2	1.4	1.5	1.3	1.4	1.5	1.6	3.5
<u>NUTRIENTS</u>								
AMMONIA	.018	.012	.010	.002	.002	.006	.004	.004
TOTAL KJELDAHL NITROGEN	.22	.21	.25	.22	.24	.28	.23	.27
PHOSPHORUS	.012	.012	.018	.012	.015	.015	.011	.015
<u>METALS</u>								
MANGANESE	.026	.035	.039	.037	.048	.037	.039	.064
<u>INDUSTRIAL GROUP</u>								
B.O.D.	0.6	0.6	0.8	1.0	1.0	1.2	N.A	N.A
C.O.D.	<10	18	16	12	48	12	N.A	N.A
SUSPENDED SOLIDS	3.0	1.6	2.7	2.7	3.1	2.8	3.2	2.9
DISSOLVED SOLIDS	46	49	49	49	49	49	49	55
PHENOLS	2	4	2	3	4	5	6	18
TANNINS AND LIGNINS	0.5	0.5	0.5	1.0	1.0	1.0	N.A	N.A
ORGANIC CARBON	7	7	9	7	7	8	9	13

* All concentrations in mg/L except conductivity (umhos/cm), pH, colour (Hazen units) and phenols (ug/L).

N.A. not available, samples lost in transit.

TABLE 3

STURGEON RIVER 1977

		DISSOLVED OXYGEN (mg/L) 2 METRES FROM THE BOTTOM							
DATE	STATION	1	2	3	4	5	6	7	8
June 24		9.4	8.8	8.6	8.2	8.0	7.0	6.6	8.4
June 26		8.9	8.5	8.6	8.1	7.9	7.4	7.3	6.0
June 28		9.2	9.3	9.2	8.6	8.4	7.4	7.2	7.3
August 9		8.1	7.7	7.8	7.1	6.7	5.0	4.2	2.8
August 12		8.5	8.1	7.8	7.0	6.6	5.2	4.9	8.9

TABLE 4

STURGEON RIVER 1977

		CHLOROPHYLL <u>a</u> (ug/L)							
DATE	STATION	1	2	3	4	5	6	7	8
June 24		1.0	0.6	1.4	0.5	1.0	1.0	1.2	0.6
June 28		1.0	1.0	1.6	1.1	0.3	0.2	0.4	0.7
August 9		0.4	0.9	1.2	1.7	0.8	0.7	0.2	0.4
August 12		1.0	1.0	1.2	0.9	0.8	1.2	1.2	0.8

Results of Secchi disc light transparency measurements are shown in Figure 4.

On all days of regular effluent discharge a noticeable reduction of water clarity was recorded downstream of the Mill discharges. On Sunday June 26 while Mill effluent discharges were reduced, an improvement in downstream water clarity was observed.

Chlorophyll a concentrations presented in Table 4 were low throughout the length of the river and did not show patterns of occurrence related to industrial or municipal outfalls.

2. Bacteriological Water Quality

Statistically evaluated bacteria distribution summaries for the June 25 and August 10 survey periods are shown in Figures 5 and 6. Data for total coliforms (TC), fecal coliforms (FC), fecal streptococci (FS) and Pseudomonas aeruginosa (PA) are presented.

In June (Figure 5) two distinct statistical zones of bacterial density were identified. The Group A zone of relatively low geometric mean density was located upstream of the Abitibi Forest Products outfall. The Group B zone, downstream of the Mill was characterized by grossly elevated numbers of bacteria. The highest single bacterial input was at station 1, the east outfall of the Mill (Plate 1). Bacterial densities were greatly in excess of Ministry of the Environment recreational use criteria.

SECCHI DISC VISIBILITY

STURGEON RIVER 1977

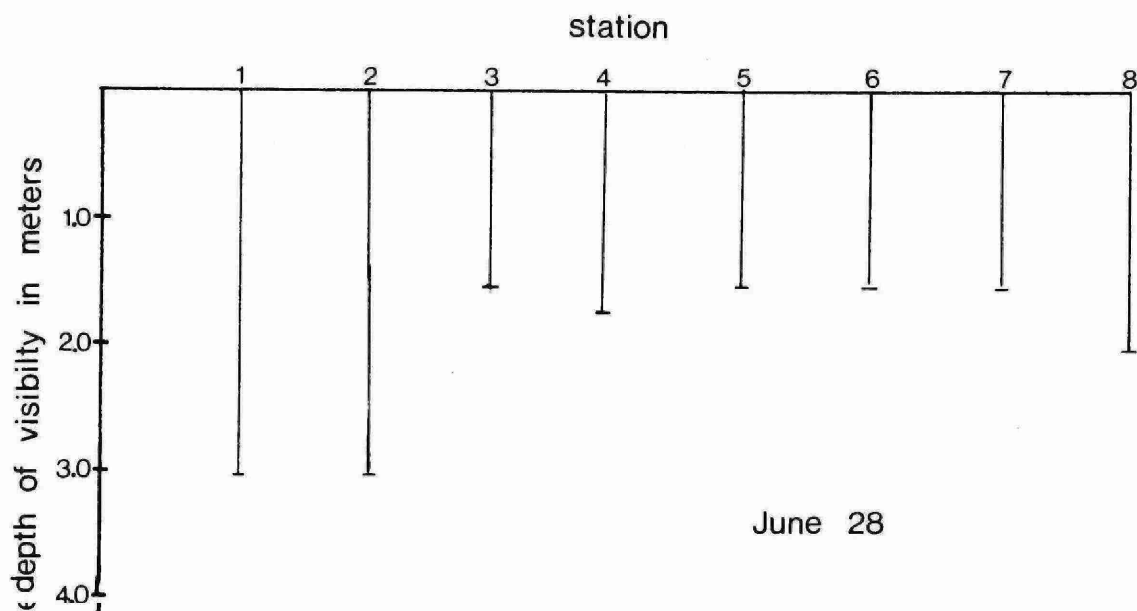
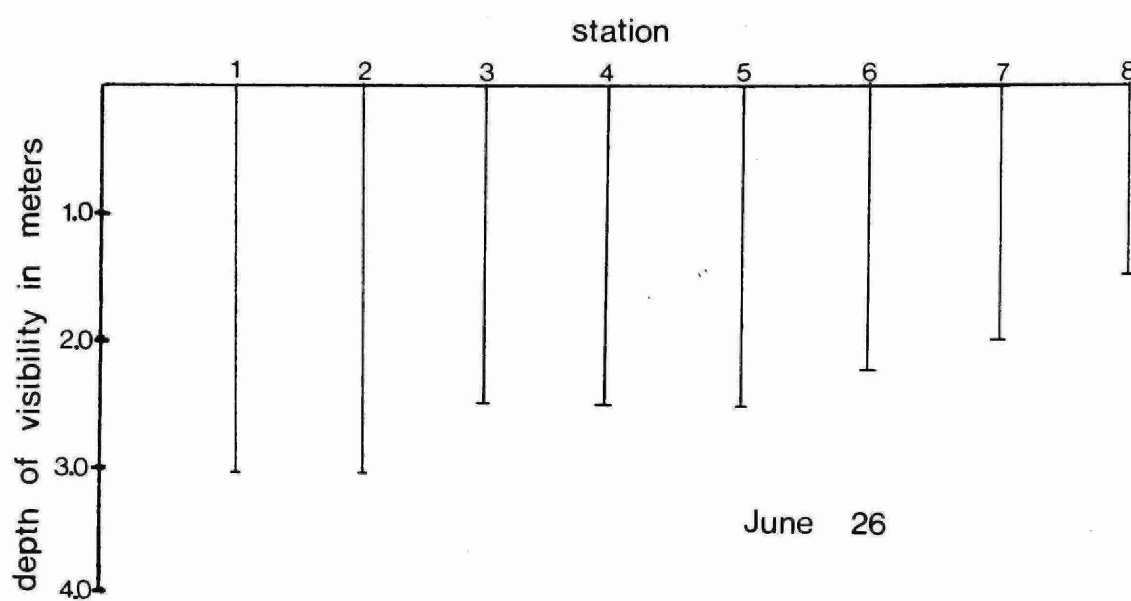
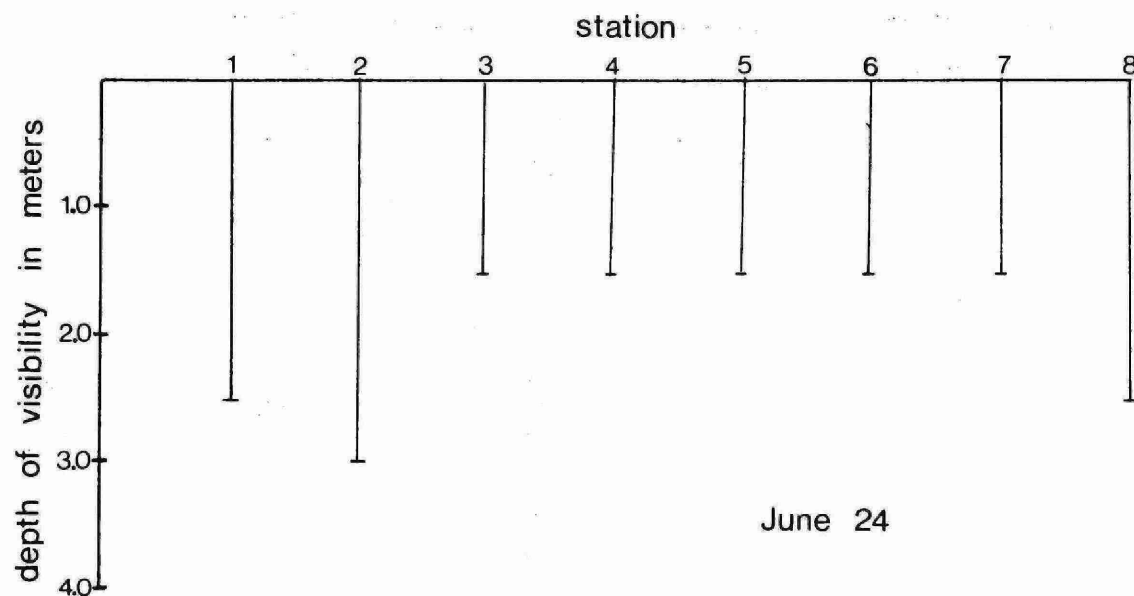


FIG 4 a

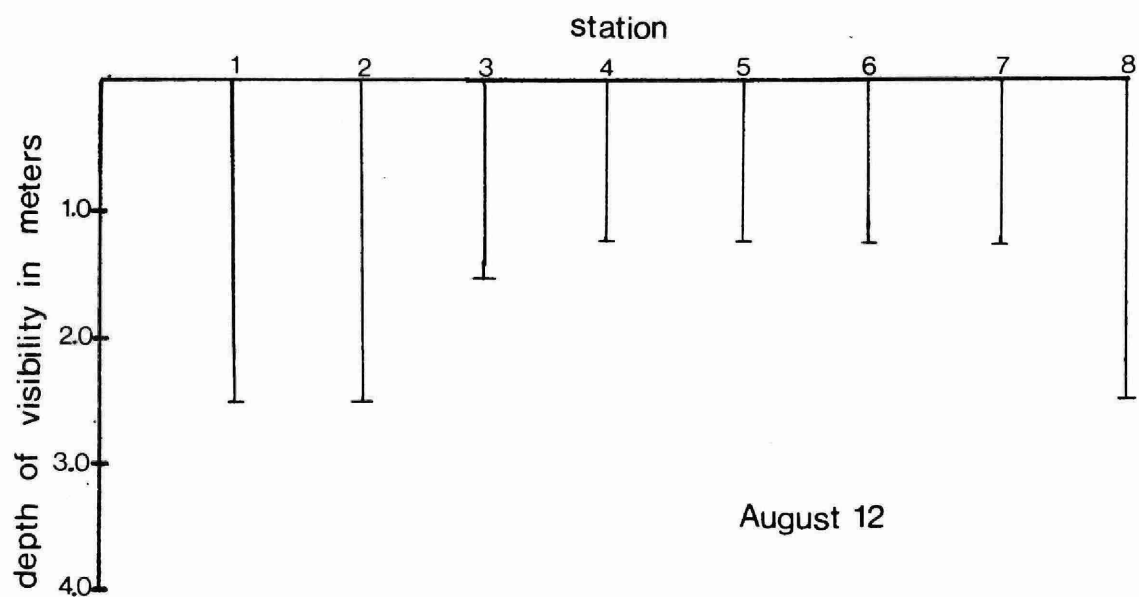
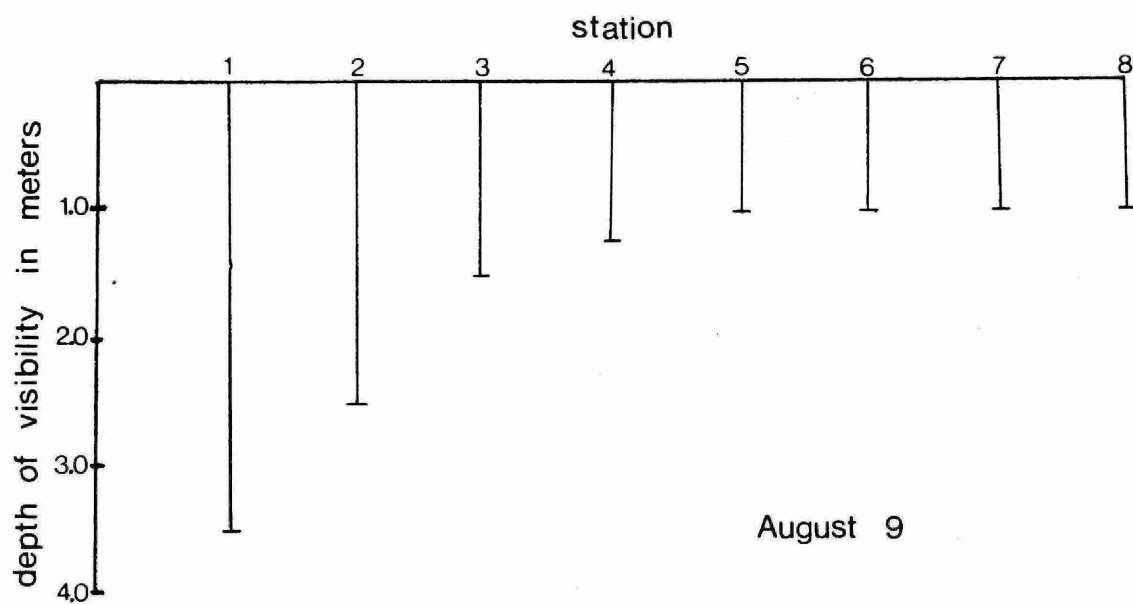
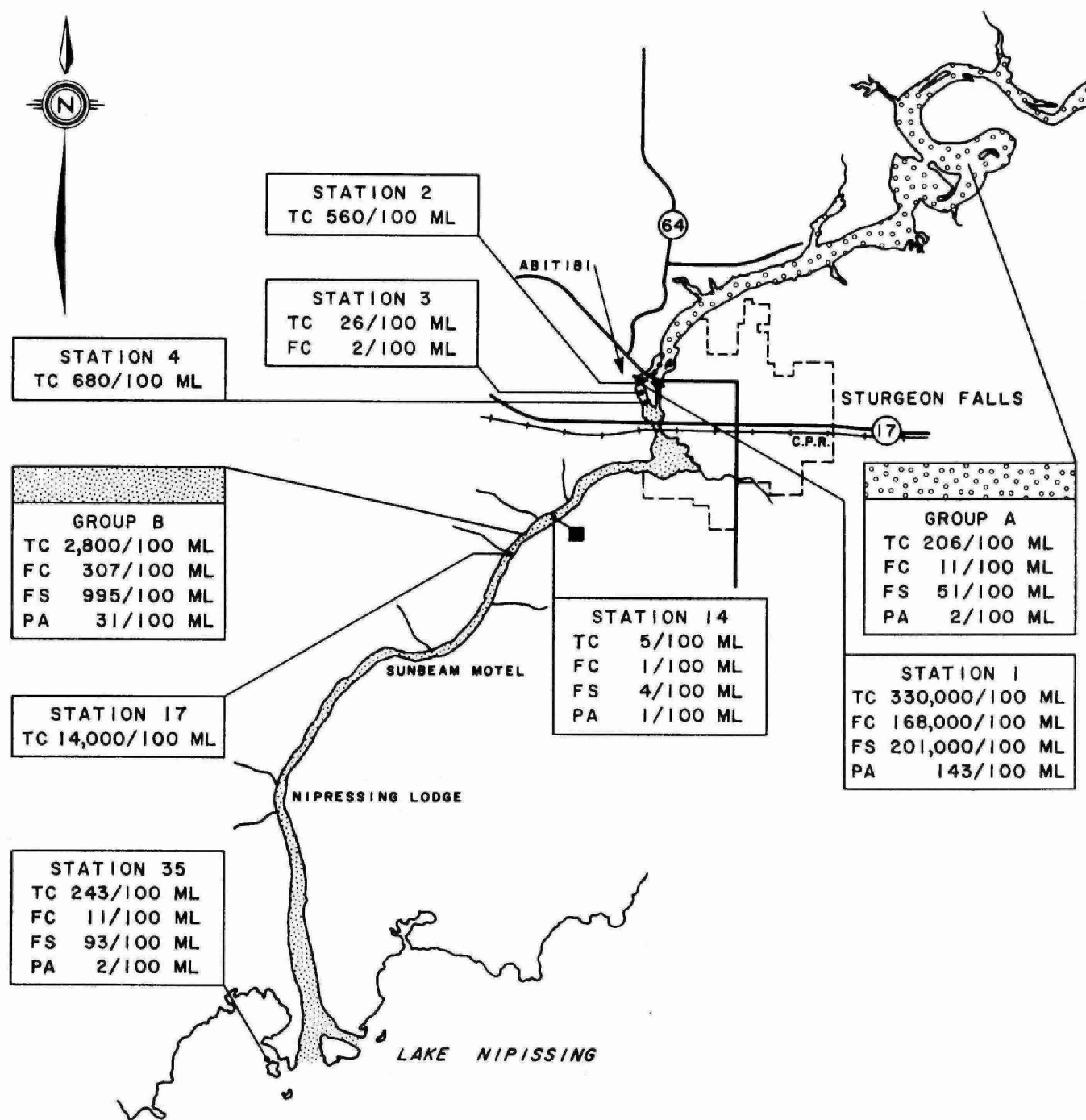


FIGURE 5 - DISTRIBUTION OF BACTERIA FOR THE
JUNE 25 TO JUNE 29 SURVEY.

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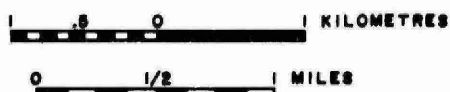


LEGEND

- DAM
- SEWAGE TREATMENT PLANT
- FLOATING LOG-CHAIN BARRIER

GROUP OR STATION
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
PA GM/100 ML

PA - PSEUDOMONAS AERUGINOSA
GM - GEOMETRIC MEAN



MINISTRY OF THE ENVIRONMENT

RECREATIONAL LAKES PROGRAM
STURGEON RIVER
1977 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: A.R.S.

DATE: FEB., 1978

CHECKED BY:

DRAWING NO: 7997

In August (Figure 6), three separate zones of bacterial density were found. Upstream of Abitibi Forest Products, the Sturgeon River was categorized as Group A with low bacterial density. Immediately below the outfalls, a group B zone of increased bacterial density graded downstream into a Group C area with extremely high bacterial numbers. The main outfall from the Mill (station 1) was the main bacterial input.

The mean bacterial densities of each sampling station were summarized in Figure 7 for the June survey and Figure 8 for the August sampling period. The large input of bacteria from Abitibi Forest Products (station 1) and the subsequent effect on downstream bacterial numbers was evident. Densities of fecal coliforms and Pseudomonas aeruginosa rose in downstream areas.

The sewage treatment plant effluent (station 14) contained relatively few bacteria.

During both the June and August surveys, large progressive increases in heterotrophic bacterial densities were observed downstream of the Mill (Table 5).

Taxonomic classification of bacteria from the river and the Abitibi effluent outfalls led to a high rate of confirmation of the opportunistic pathogen Pseudomonas aeruginosa (Table 6).

Identification of fecal coliforms isolated from three locations including upstream, Mill outfall and downstream samples

FIGURE 6 - DISTRIBUTION OF BACTERIA FOR THE
AUGUST 10 TO AUGUST 14 SURVEY.

34

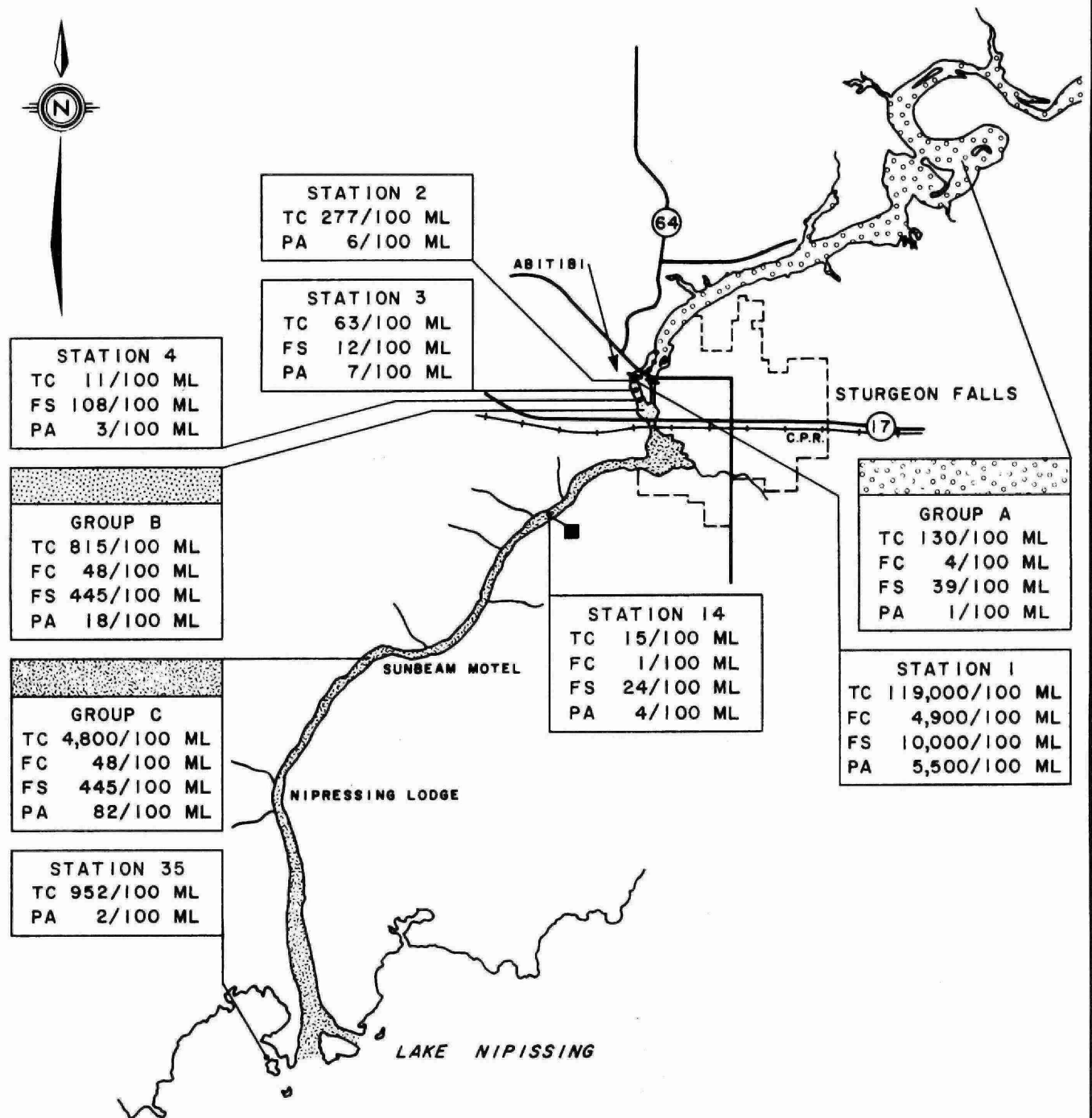


FIGURE 7 - GEOMETRIC MEAN LEVELS OF FECAL COLIFORMS, FECAL STREPTOCOCCUS AND *PSEUDOMONAS AERUGINOSA* VS STATIONS ON THE STURGEON RIVER DURING THE JUNE 25-29, 1977 SURVEY.

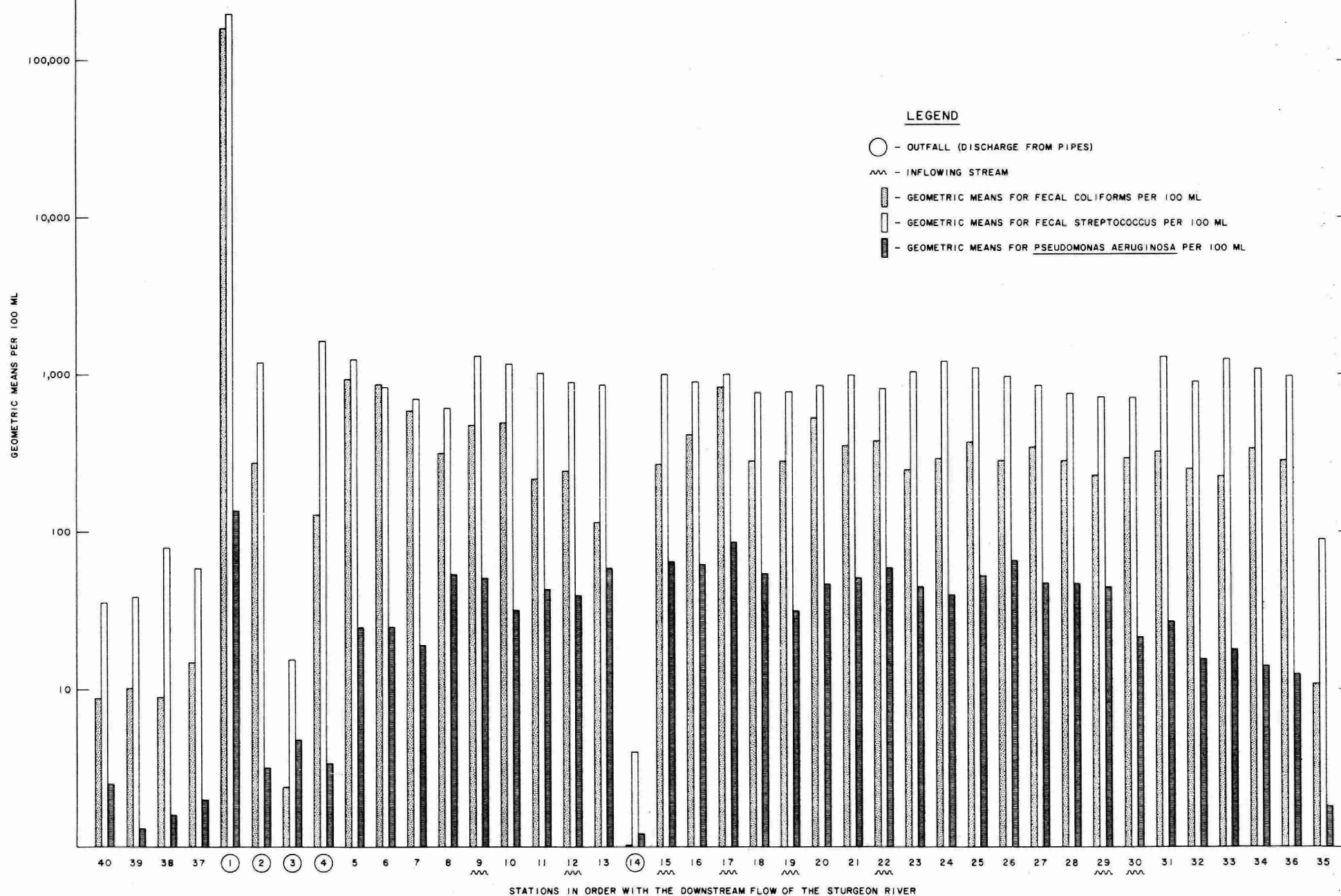


FIGURE 8 - GEOMETRIC MEAN LEVELS OF FECAL COLIFORMS, FECAL STREPTOCOCCUS AND *PSEUDOMONAS AERUGINOSA* VS STATIONS ON THE STURGEON RIVER DURING THE AUGUST 10-14, 1977 SURVEY.

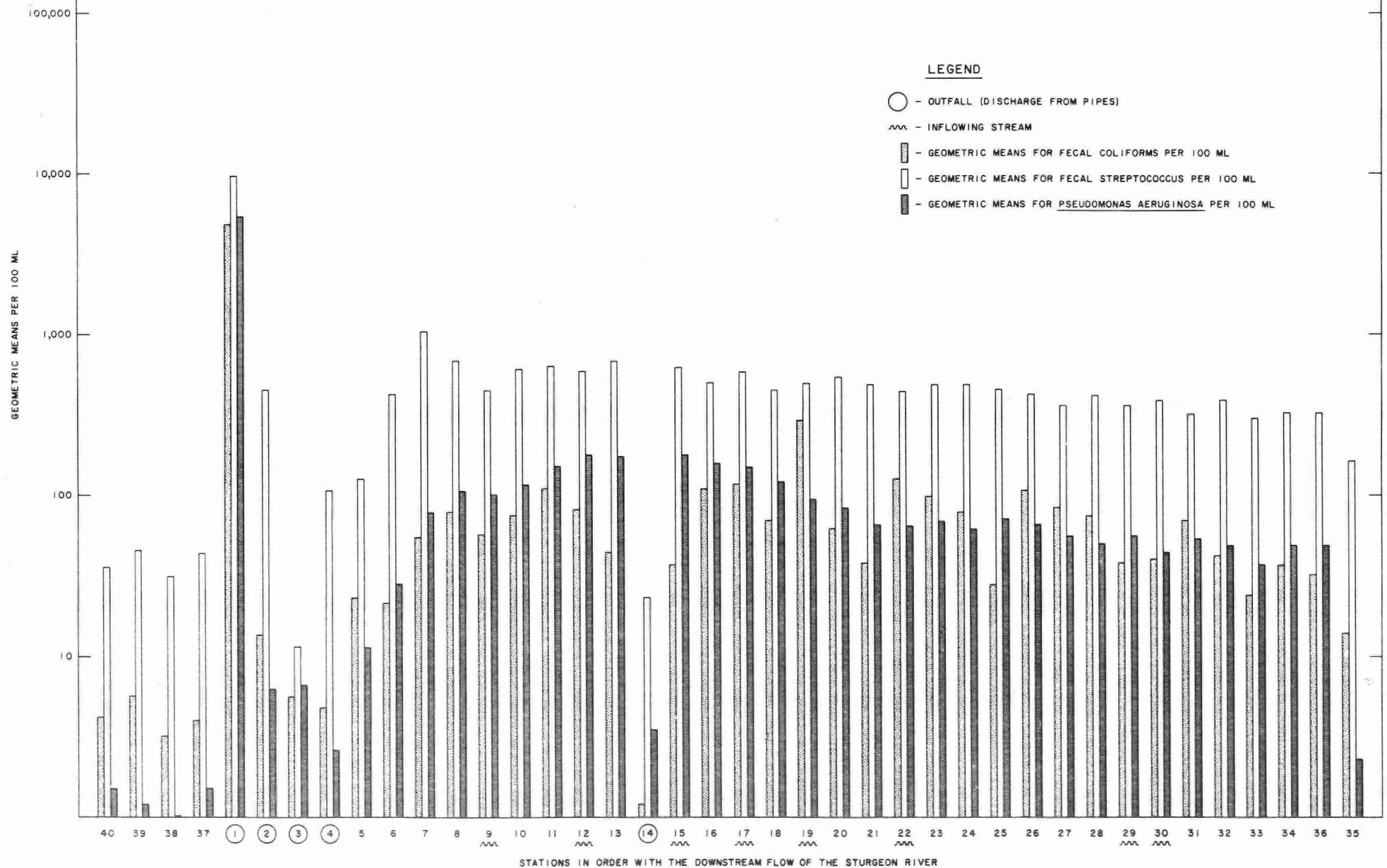


TABLE 5

Geometric Mean Densities (per 1.0 ml) of Heterotrophic Bacteria

	Upstream from Sturgeon Falls (Stations 37 & 40)	Station 6	t-Test	Downstream from Sturgeon Falls (Stations 20 & 28)	t-Test
June	935	7,730	*	58,600	*
August	1,980	15,100	*	67,500	*

* Mean densities of Heterotrophic Bacteria at different locations were found to be significantly different by a t - test (95% level of confidence)

TABLE 6

Confirmation of Identification of Pseudomonas aeruginosa Isolated
during the Sturgeon River Survey

Location	Number of Colonies	Identification	% P. <u>aeruginosa</u>
Abitibi Outfalls (Stations 1 & 3)	51/53 2/53	<u>P. aeruginosa</u> No Identification	96.2 -
River below the dam	21/22 1/22	<u>P. aeruginosa</u> No Identification	95.5 -
Total	72/75	<u>P. aeruginosa</u>	96.0

TABLE 7

Identification of Fecal Coliforms Isolated From Three
Locations During the Sturgeon River Survey

% Species Composition

Location	E. Coli	K. Pneumoniae	E. Cloacae	E. Agglomerans	Oxidase Positive	No Identification Available
Upstream from Abitibi	100.0	-	-	-	-	-
Abitibi Main Outfall	3.7	59.2	-	3.7	33.3	-
Downstream from Abitibi	13.2	54.7	3.8	-	16.9	11.3

showed that E. coli were the only fecal coliform present in the river upstream of the Mill. The fecal coliforms isolated in the Mill outfalls and downstream of the Mill showed greater species diversity resulting in the isolation of large numbers of the thermotolerant opportunistic pathogen Klebsiella pneumoniae and oxidase positive bacteria (Table 7).

3. Sediment Composition and Invertebrate Presence

The results of the sediment dredging surveys undertaken in June and August (Figure 2) were combined and are presented in a tabulated form (Table 8). Odour description and biological organism numbers were based on August samples.

- "a" samples were taken 5 metres from the east bank
- "b" samples were taken in the middle of the river
- "c" samples were taken 5 metres from the west bank.

Generally, wood fiber which had the appearance of soggy shredded wheat was found the length of the river downstream of the Mill while larger particles of wood debris were concentrated between chemical sampling stations 3 and 4 (Figure 2).

Macroinvertebrate diversity indices calculated from the Shannon-Weaver function were based on equalized macroinvertebrate densities per square metre of sediment. Station indices are shown in Table 8 on the extreme right.

TABLE 8

LOWER STURGEON RIVER SEDIMENT SURVEY 1977

<u>STATION</u>	<u>SAMPLE DESCRIPTION</u>	<u>WOOD FIBER</u>	<u>ODOUR</u>	<u>MACRO-INVERTEBRATES</u>		<u>DIVERSITY INDEX</u>
1	a clay - organic ooze	none	earthy	clam 1	worm 1	
	b clay - organic ooze, some aquatic vegetation	none	earthy	snail 7	midge 3	2.63
	c clay - organic ooze	none	earthy	amphipod 8	mayfly 3	2.63
2	a clay - organic ooze	none	earthy	leech 2	dragonfly 2	
	b clay - organic ooze, some wood debris	none	none	clam 2	midge 3	
	c clay - organic ooze, lots of bark debris	none	none	amphipod 3	caddis 1	
3	a gritty sand, wood fiber, wood chips, assorted debris, gum wrapper, cigarette butts, road sweepings	present	none	leech 1	mayfly 4	2.82
	b wood particles, axe size wood chips, traces of fungus on wood chunks, at edge of fast water	present	none	worm 2	dragonfly 1	
	c 50/50 sandy grit, wood fiber, some pebbles	present	foul	snail 2	midge 6	0.82
			faint oily			

.../2

<u>STATION</u>	<u>SAMPLE DESCRIPTION</u>	<u>WOOD FIBER</u>	<u>ODOUR</u>	<u>MACRO-INVERTEBRATES</u>	<u>DIVERSITY INDEX</u>
4	d wood and bark chips, some slime on wood particles	present	foul but faint	snail 4 midge 20	0.66
	e gritty sand with granitic pebbles, almost gravel lots of wood fiber	present	faint		
	a sandy grit	present	little	snail 33	1.08
	b sandy grit, bark and wood chips		foul but faint	midge 39 leech 1	
5	c solid clay, wood fiber on surface	present	none		0.88
	a organic ooze, clay and some grit	present	none		
	b sandy grit and fiber	present	none	snail 14 midge 6	
	c clay lumps and sandy grit	present	none		

<u>STATION</u>	<u>SAMPLE DESCRIPTION</u>	<u>WOOD FIBER</u>	<u>ODOUR</u>	<u>MACRO-INVERTEBRATES</u>	<u>DIVERSITY INDEX</u>	
	a	grey clay ooze, some gritty sand	present	none	clam 2 snail 46	
6	b	sandy grit, some bark chips covered with brownish slime	present	none	midge 35 worm 1	1.35
6	c	organic ooze, wood chips bark debris, leaf litter	present	grassy		
	a	ooze in gray clay matrix, lots of shredded wheat- like fiber	present	none	snail 24 midge 193	0.54
7	b	gravel and lumps of clay, little fiber, some bark chunks	present	none	worm 1	
	c	clay silt and organic ooze, some sand	present	none		

../4

<u>STATION</u>	<u>SAMPLE DESCRIPTION</u>	<u>WOOD FIBER</u>	<u>ODOUR</u>	<u>MACRO-INVERTEBRATES</u>	<u>DIVERSITY INDEX</u>
8	organic, clay ooze, vegetation debris	present	grassy	clam 3 midge 3 snail 2 worm 2 amphipod 1 mayfly 1 Isopod 1 leech 2	2.86
S ₃	organic ooze, vegetation debris	none	grassy		

A greater variety of aquatic life was observed in the sediment samples taken upstream of Sturgeon Falls and in Lake Nipissing than in the lower stretch of the river itself.

DISCUSSION

1. Aesthetics and Chemical Water Quality

Aesthetics

By definition, aesthetics pertain to the appreciation of visually pleasing characteristics of a subject. In the case of the Sturgeon River survey, the term "aesthetics" was used to describe the visual impressions of the sampling crew with respect to the comparative appearance of the river upstream and downstream of the Town of Sturgeon Falls and the Abitibi Mill.

As stated in the results section of this report, there was a deterioration in the aesthetic quality of the Sturgeon River immediately below the Mill outfalls during both survey periods.

That area below the effluent outfalls, where the Mill discharges are diluted by the flow of the Sturgeon River, is defined as a mixing zone. Here, by definition, an effluent of quality characteristics different from those of the receiving water is in transit and is progressively diluted from its source to the receiving system (Lake Nipissing).

Water Quality Objectives for the Province of Ontario pertinent to aesthetic quality state that:

- the mixing zone should be aesthetically acceptable.

Mixing zones should not contain:

- materials which form objectionable deposits, i.e. scums, oils or floating debris; substances producing objectionable colour, odour, taste or turbidity;
- substances which produce objectionable growths of nuisance plants and animals.

Whether the mixing zone was aesthetically acceptable during the survey is debatable. The Mill effluents produced foaming turbidity plumes along both banks of the river, which, upon dissipation still contributed to a significant reduction in water clarity at downstream locations.

The discharge of wood fiber particles in the Mill effluent resulted in the suspension of these particles by upwelling currents as far downstream as the Highway 17 bridge.

There were extensive growths of the slimy, cotton-wool-like sewage fungus on the rocks below the effluent outfalls. During the August survey period amorphous pieces of the sewage fungus were breaking away from their substrates below the outfalls and were being carried downstream by the flow. The visible suspension of the slimy, cotton-wool-like pieces down to the Highway 17 bridge detracted from the aesthetic quality of the area below the Mill.

The constant bubbling of flammable gases (likely methane) rising from the sediments in the bay area adjacent to the fast water mixing zone (Figure 2, 3a) was also not aesthetically pleasing. The methane gas was likely generated through

bacterial action under chemically reducing conditions on the wood fiber and debris deposited in the bay.

Although the sewage fungus was visible only to the Highway 17 bridge and had no apparent effect on downstream recreational use during 1977, complaints regarding profuse growths of the slime were received specific to the 1976 summer period. The slimy, cotton-wool-like masses were present in such large concentrations that sport fishing was reportedly affected right down to the mouth of the river. Fishing lines, anchor ropes and minnow buckets suspended in the lower Sturgeon River rapidly became coated with nuisance slime masses making fishing extremely unpleasant.

Sewage fungus can be a serious problem in rivers receiving easily degradable organic waste.

It is a problem usually associated with poorly treated sewage effluents but which also occurs in the food, drink and paper industries. When environmental conditions are suitable, it forms a massive growth of slimy cotton-wool-like plumes which can rapidly colonize all submerged surfaces.

The problem is complicated by the fact that sewage fungus infestations often occur in rivers and streams that are considered to be in good shape with respect to water quality criteria such as dissolved oxygen and biochemical oxygen demand.

Microscopic examination of a sample of the greyish-white cottony slime scraped from stones below the Abitibi Mill outfalls revealed that a major portion of the biomass was comprised of non-septate, branching fungal hyphae containing cellulose plugs, typical of the

genus Leptomits. A minor portion of the biomass was composed of apparently non-motile, rod shaped bacteria approximately 2 u wide and 5 u long, generally in chains. These bacteria were not identified but may be of the genus Bacillus.

It is the presence of the fungus, Leptomits, which gives the material its cottony macroscopic appearance. Leptomits is one organism of many which are often referred to as "sewage fungus". It is commonly found in streams rich in organic matter. Depending on environmental conditions, it may be the only component of the growth or it may be associated with the growth of other organisms such as the sheathed bacterium Sphaerotilus, other fungi such as Geotrichum or Fusarium, or the sulphur oxidizing bacterium Beggiotoa.

According to Curtis (1969), Leptomits generally requires a high oxygen concentration and acid pH for growth. Although it is capable of growth over a pH range of from 2.5 to 7.5, its optimal range is from 2.9 to 5.4. The organism generally utilizes low molecular weight fatty acids (but no sugars) and generally requires organic nitrogen as opposed to nitrates or ammonia as its nitrogen source. An infestation of Leptomits below a paper industry outfall would not be unreasonable considering the fact that organic carbon and nitrogen would be readily available in the process wastes.

The shoreline bands of aquatic vegetation present in the Lower Sturgeon River and the extremely dense growths at the mouth of the river were considered to be common phenomena of shallow, near-shore areas with organic sediments.

The observed reduction in fishery quality and productivity in the Sturgeon River during the August survey period was thought to be a normal occurrence related to seasonal changes in water levels, temperature, light intensity and other environmental factors affecting the movement and behavior of fishes.

Water Chemistry

a) Characterization Group

The characterization parameters are a measure of general river water composition.

Hardness is a measure of the soap consuming power of water due to the presence of metallic cations principally calcium and magnesium. It is also used as an indication of mineral content. Concentrations below 100 mg/L are regarded to be indicative of soft water conditions.

Water in the Sturgeon River was moderately soft averaging 29 mg/L. Downstream of Sturgeon Falls no appreciable change in hardness was observed.

Alkalinity is used to assess the buffering capacity of water or its ability to resist pH change from acidic inputs. Generally, alkalinity values of approximately 20 mg/L are considered to be desirable so that natural productivity is not jeopardized.

A slight increase in alkalinity from upstream concentrations of 18 mg/L to 21 mg/L downstream of the Mill was not considered to be significant.

Conductivity is a measure of electrical resistance and is correlated with the dissolved inorganic solids content of water.

In the Sturgeon River conductivities indicative of moderately dilute conditions (70 to 85 umhos/cm) were measured. An increase, amounting to approximately 10 umhos/cm, was observed downstream of the Abitibi Forest Products discharges suggesting the addition of dissolved substances to the river. However, this increase was not of concern.

pH is a measure of the hydrogen ion concentration. A reading of 7 is considered neutral while higher values are termed basic, and lower values are acidic. A favourable range for aquatic life is between 6.5 and 8.5.

Although arithmetic mean values showed progressively acidic conditions downstream of Abitibi Forest Products, no problems were indicated as the pH readings obtained were within the favourable range.

Colour in natural surface waters is primarily associated with the presence of humic acids derived from the decomposition of plant material. Colour determinations, which measure the intensity of the yellow-brown hue, include the colour due to dissolved substances as well as the colour contributed by suspended matter. Most naturally coloured waters are harmless; however, a drinking water objective of 5 Hazen units is specified for aesthetic reasons.

Although colour values in upstream samples (STN 1 and 2) ranged from 15 to 40 Hazen Units, average concentrations in downstream samples were higher in comparison ranging from 20 to 70 units.

Calcium is an essential element for all life forms. It is non-toxic and presents no known health hazards. Calcium is the major contributor to water hardness.

Concentrations of calcium found in the Sturgeon River were moderately low (8 mg/L) and were unaffected by industrial discharges.

Magnesium is an essential element for the life functions of all plants and animals. It is a contributor to water hardness. Concentrations in excess of 125 mg/L can exert a laxative effect upon ingestion.

Magnesium concentrations in the Sturgeon River were low (2.2 mg/L) and not influenced by industrial activity.

Sodium is an important element for all life forms and is generally considered non-toxic. Patients with high blood pressure are usually warned to avoid consumption of water containing more than 50 mg/L sodium. It can be added to natural waters via industrial effluents, sewage treatment discharges and from road drainage when salt is used to control road ice.

Sturgeon River sodium concentrations were found to be low even with effluent additions from Abitibi and the sewage treatment plant which raised background concentrations from approximately 1 mg/L to the 3 to 4 mg/L range.

Potassium is also a non-toxic essential nutrient for life forms especially plants.

Although a slight increase in potassium concentrations was observed downstream of the Mill outfalls, total quantities both upstream and downstream of the lake were very low (.55 - .65 mg/L).

Chloride poses no direct health hazard but a salty taste may be noticed if concentrations exceed 250 mg/L. The major source of chloride is urban runoff which often contains high concentrations of chloride in the winter time due to road application of salt.

Chloride concentrations were low at all stations (.8 - 1.5 mg/L).

Sulphate is a widely distributed ionic component in natural waters normally varying between 10 and 80 mg/L. Concentrations above 250 mg/L tend to exert a laxative effect when ingested.

The 14 to 16 mg/L concentration range observed for the Sturgeon River was not considered to be above natural concentrations for this area.

b) Nutrients

The nutrient elements nitrogen, phosphorus and carbon are essential for the growth of aquatic organisms. However, excess concentrations originating in industrial effluents, sewage treatment plant discharges, and certain land use practices can have negative effects on water quality. Excess nutrients can contribute to profuse growths of algae, slimes and aquatic vegetation.

Ammonia is the initial breakdown product during the decomposition of nitrogenous organic material. Its presence in high concentrations is not desirable due to its toxic properties, high oxygen demand and its ability to promote the excessive growth of algae and aquatic plants.

Concentrations of ammonia in the Sturgeon River were generally low and much below toxic levels (.002 - .022 mg/L). An interesting occurrence was the decline in average ammonia

concentrations from .017 to .003 mg/L downstream of the Mill discharges suggesting utilization of ammonia as a nitrogen source by aquatic organisms.

Total Kjeldahl Nitrogen is a measure of nitrogen in the trinegative state including that in ammonia and in organic forms like protein, amines and urea. Kjeldahl nitrogen results are used in the interpretation of the effectiveness of waste stabilization processes and can be an indication of the addition of organic nitrogen to a receiving system.

Concentrations of Kjeldahl nitrogen averaged 0.31 mg/L upstream of the Mill and approximately .40 mg/L downstream of it. These concentrations are considered to be moderate for natural surface waters and are not generally thought to be problematic. However, because the addition of organic nitrogen may fuel the downstream growth of sewage fungus, the increase of total Kjeldahl nitrogen observed may have significance.

Nitrite is an unstable intermediate nitrogen form in the oxidation of ammonia to nitrate.

Concentrations of nitrite were very low at all times (.002 - .003 mg/L) and not significant in the water chemistry.

Nitrate is the most highly oxidized form of nitrogen in aquatic systems. High concentrations of nitrate are objectionable because their nutritive properties promote the excessive growth of algae and other aquatic plants. A maximum acceptable concentration for domestic water supplies in Ontario is 10 mg/L to avoid infant methemoglobinemia.

Overall, concentrations of nitrate in the Sturgeon River were low averaging .015 mg/L above the Mill and .006 mg/L below it. The reduction in average nitrate concentrations

below the Mill suggests rapid utilization of nitrates by aquatic organisms.

Total phosphorus Artificial inputs of phosphorus via waste water and land runoff play a significant role in promoting the overabundance of algae and aquatic plants.

Concentrations of phosphorus in lakes are considered to be potentially problematic when values greater than .020 mg/L are found. In river systems, because of water movement, concentrations up to .030 mg/L are generally tolerable.

Total phosphorus downstream of the Abitibi Forest Products effluent discharges increased to approximately .020 mg/L from an upstream average of .012 mg/L and declined to a concentration of .015 mg/L near Lake Nipissing.

The increases in total phosphorus observed downstream of the Mill are not thought to be significant with respect to potential water quality deterioration in the Sturgeon River.

Inorganic carbon is a measure of the carbon in the bicarbonate form that is readily available to support biological productivity.

Concentrations of inorganic carbon in the Sturgeon River were consistently in the low 3 to 7 mg/L range and exhibited no significant increases below industrial and municipal outfalls.

c) Metals

There are many dissolved types of metals in water some of which are toxic to aquatic life. Investigation of metal concentrations in the Sturgeon River showed concentrations of copper, zinc, lead, nickel cadmium and arsenic to be low and near the analytical detection limits.

Iron is a component of hemoglobin and an essential element for all life forms. It is non-toxic at high levels but objectionable in domestic water supplies because of the colour and the bitter taste it imparts. The water quality objective in domestic supplies is 0.3 mg/L.

No large increases in iron were measured downstream of Abitibi Forest Products. The iron concentrations detected (.10 - .31 mg/L) were not significant in affecting water quality.

Manganese in trace quantities is essential for the proper nutrition of both plants and animals. Although it is non-toxic at levels commonly encountered in water supplies, it causes unpleasant tastes, stains laundry and plumbing and encourages the growth of objectionable micro-organisms at treatment plants. The maximum acceptable concentration of manganese for domestic water supplies in Ontario is 0.05 mg/L.

Concentrations of manganese in the Sturgeon River upstream of the Abitibi discharges were moderate (.024 - .044 mg/L) and increased downstream to concentrations around the acceptable limit of 0.05 mg/L.

Although manganese levels near the acceptable limit were achieved from time to time, conditions were not problematic.

d) Industrial Chemical Parameters

B.O.D.₅ or biochemical oxygen demand is a measure of dissolved oxygen required for the aerobic bacterial stabilization of decomposable organic matter in a 5 day period.

The most frequent damage caused by the discharge of organic wastes to natural waters is the subsequent reduction of dissolved oxygen concentrations to levels which cannot support normal aquatic life.

For warm water biota, concentrations of dissolved oxygen above 47% saturation are recommended. At temperatures above 20°C oxygen concentrations must remain above 4 mg/L.

In the Sturgeon River, B.O.D. upstream of the Abitibi Forest Products outfalls averaged less than 1 mg/L. B.O.D. values downstream of the Mill discharge area ranged from 1.6 to 8.5 mg/L in the river averaging 3.5 mg/L, and from 0.5 to 8 mg/L in Lake Nipissing averaging 2.9 mg/L.

The highest average B.O.D. of 4.5 mg/L was recorded downstream of the sewage treatment plant outfall at station 5, Figure 2.

The highest B.O.D. values for chemical sampling stations 4 through 8 were measured on August 9 following a period of sunny, warm, dry and windless weather. The B.O.D. values

observed were not solely attributable to industrial discharges but were a combination of the discharges and low river flow conditions resulting in less dilution of the industrial wastes. (River flows during survey dates are shown in the appendix).

The effect of Biochemical Oxygen Demand on the river can be evaluated by an examination of dissolved oxygen concentrations during the sampling period. Table 3 which summarizes oxygen concentrations measured 2 m from the river bottom, showed a gradual reduction in dissolved oxygen downstream of the Mill outfalls located upstream of station 3. However, the dissolved oxygen objectives for warm water biota which indicate that dissolved oxygen concentrations should remain above 4 mg/L at all times, were met at all locations including August 9 at the mouth of the river where low concentrations of 4.2 mg/L were recorded. In the lake, oxygen concentrations were very low on this date as a concentration of 2.8 mg/L was recorded at chemical sampling station 8.

The significance of low dissolved oxygen concentrations in Lake Nipissing is discussed in the physical group section.

Because dissolved oxygen concentrations in the river remained above 4 mg/L, the B.O.D. attributable to industrial sources could not be cited as a significant factor in water quality degradation during the duration of the survey. However, the reduction of dissolved oxygen concentrations at the mouth of the river on August 9 during lower flow suggests that problematic conditions induced by B.O.D. may occur when river flows are reduced.

C.O.D. or chemical oxygen demand is a measure of the oxygen required to oxidize susceptible organic and inorganic compounds under vigorous chemical oxidizing conditions. C.O.D. results do not necessarily relate to the oxygen consumption of a water receiving industrial waste but they do approach the ultimate carbonaceous oxygen demand that may eventually be exerted.

Increases in chemical oxygen demand more than double the 22-25 mg/L average observed in the upstream samples were noted below and downstream of the Mill outfalls. The significance of the C.O.D. increase on existing water quality was unknown; however, it was an indication of the addition of carbonaceous compounds which may have been nutrient sources for the growth of sewage fungus.

Suspended solids measurements are a determination of the quantity of material that can be removed from a water sample by filtration.

Determination of suspended solids in the Sturgeon River showed a two fold increase downstream of Abitibi Forest Products from 2.8 mg/L to approximately 5 mg/L. Maximum values were recorded at chemical sampling stations 3 and 4 (5.6 - 6.9 mg/L). Even so, concentrations were generally low and not problematic.

The sighting of suspended wood fiber and pieces of sewage fungus near sample site 3 led to the expectation of higher concentrations of suspended solids; but, water samples taken at this location failed to contain the suspended material observed

in the river.

Dissolved solids determinations are a measure of the solid material that remains as a residue after evaporation of a filtered portion of a water sample. Dissolved solids values are closely associated with conductivity which has already been discussed.

Increases of dissolved solids downstream of Sturgeon Falls from 48 to 55 mg/L were not considered to be significant.

Phenols, or reactive phenolics, are a class of organic chemical substances having one or more hydroxyl groups attached directly to an aromatic ring. Results of phenol analysis are presented in micrograms per litre (ug/L) or parts per billion.

Phenolic wastes are derived from petroleum, coke, and chemical industries; wood distillation; and domestic and animal wastes. Their presence in chlorinated domestic water supplies can impart unpleasant tastes. For this reason Ontario drinking water criteria suggest virtually absent concentrations of 1 ug/L. Phenolic compounds in low concentrations approaching 1 ug/L have been implicated in the tainting of fish flesh and concentrations above 100 ug/L are potentially toxic to some species of fish (E.P.A. 1973).

As shown, concentrations of phenols in the Sturgeon River increased below the Mill outfalls. Upstream concentrations averaged 1.5 ug/L while downstream values averaged 27 ug/L.

Although concentrations of phenols downstream of the Abitibi Forest Products outfalls exceeded drinking water criteria and were within the range in which fish tainting was possible, there were no local reports of unpalatable water or fish.

Tannins and Lignins are a group of organic compounds that are natural components of plant material and are found in surface waters as a result of normal biochemical degradation processes, or as a result of pulp and paper operations. Tannins and lignins are undesirable because they may give rise to objectionable tastes and colours in domestic water supplies even at low levels of a few mg/L.

Concentrations of tannins and lignins averaged 0.7 mg/L upstream of the Mill and increased below the Mill to average between 4 and 5 mg/L.

The significance of the increase in tannin and lignin concentrations downstream of the Mill outfalls with respect to their effect on domestic water supply taste was not known. However, the effect on the colour of the river water was evident since analytical colour values downstream of the Mill outfall were found to increase.

Organic Carbon is related to the B.O.D. and C.O.D. of a sample and is useful in assessing the efficiency of waste stabilization processes and the degree of organic pollution in receiving waters. In addition, organic carbon is an important nutrient in the growth of nuisance organisms like fungi and bacteria.

Concentrations of organic carbon averaged 7 mg/L above the Abitibi Forest Products dam, while downstream concentrations were approximately twice as high (14 mg/L).

Although a two fold increase of organic carbon does not appear to be excessive, as final concentrations are not overly high, the organic carbon emitted can be a significant nutrient source for the growths of sewage fungus found below the Mill outfalls.

Solvent extractables are defined as the total quantity of substances present in a water sample that are soluble in organic solvents. Solvent soluble materials increase the oxygen depletion rate in receiving waters and hinder oxygen exchange with the atmosphere by forming slicks.

As shown in Table 1 there was no evidence of solvent extractables being added to the Sturgeon River in the study area. Above the Mill, concentrations ranged from 1 to 1.3 mg/L while downstream they ranged from .7 to 1.3 mg/L.

Petroleum Hydrocarbons include fuels, oils, and organic solvents. Many of these substances may impart objectionable tastes and odours to domestic water supplies.

No petroleum hydrocarbons were detected in any samples.

Chemical Sampling, June 26

During the June 26 bacteriological sampling run, the sampling crew observed that the effluent discharge from plant outfalls

was modified. The main outfall (bacteriological sampling station 1 on the east side of the Mill tail race, Figure 3) was discharging an almost clear effluent in contrast to its typical cloudy, light brown discharge. The outfall on the west side of the tail race (bacteriological sample station 2) was not discharging.

(Effluent discharge volumes and river flows during the survey are shown in the Appendix).

A complete water chemistry sampling run was undertaken in order to monitor chemical water quality during this reduced discharge period.

Table 2 summarizes river water chemistry on June 26. Data are presented only for those parameters which were found to increase in concentration downstream of the Mill outfalls during regular effluent discharge periods.

On June 26, there was no appreciable difference in water chemistry between upstream (chemical sampling stations 1 and 2, Figure 2) and downstream locations (stations 3 to 7) in the Sturgeon River. In contrast, higher concentrations of most of the parameters investigated were found in Lake Nipissing (station 8).

The influence of Mill discharges on the water chemistry was apparent.

Reduced effluent discharges resulted in a below the Mill reduction of approximately 10 umhos/cm in conductivity,

a uniform low colour reading of 20 Hazen units, a decrease of 2 mg/L in sodium concentrations and a reduction in phosphorus and total Kjeldahl nitrogen concentrations to near upstream levels. Manganese concentrations increased slightly at downstream locations, but the concentration range found (.037 to .048 mg/L) was within or near the range observed for upstream locations during regular discharge periods (.024 - .044 mg/L, Table 1).

Additional reductions were measured in downstream concentrations of industrial group parameters. Biochemical oxygen demand (B.O.D.) in the lower Sturgeon River (1 mg/L) was roughly twice that of upstream samples (0.6 mg/L) but significantly lower than the 1.6 to 8.5 mg/L range observed on other days. Downstream of the Mill, C.O.D. declined to values consistent with upstream concentrations except at chemical sampling station 5 where a suspected aberrant value of 48 mg/L was recorded. This result was thought to be aberrant due to the fact that organic and inorganic constituents did not increase concurrently at this sampling location.

Suspended and dissolved solids, phenols and organic carbon concentrations downstream of the Mill were not appreciably different from upstream levels on June 26; whereas, during regular Mill discharge, increases were recorded (Table 1).

A two fold increase in concentrations of tannins and lignins (0.5 to 1.0 mg/L) between upstream and downstream stations on June 26 was considered to be insignificant as the downstream values were well below the 1.5 to 7 mg/L range found on other sampling days.

As observed during regular discharge periods, a progressive reduction of pH along with a sharp drop in ammonia concentrations also occurred downstream of the Mill on June 26. These phenomena appeared not to be related to effluent discharges.

Concentrations of most parameters (except ammonia, colour and pH) in Lake Nipissing (chemical station 8) increased over river levels; however, all parameters were within the concentration ranges usually encountered for the Lake Nipissing station.

e) Physical group

Dissolved oxygen and temperature profiles were developed at all sampling stations, three times during the June sampling period and twice during August.

Figure A in the Appendix shows that the distribution of dissolved oxygen and temperature in the Sturgeon River and the Lake Nipissing station was nearly uniform from surface to bottom at each site. A trend of decreasing dissolved oxygen, downstream of the Abitibi Forest Products outfalls, was observed during each sampling run.

Although the effluents from the Mill were warmer than the receiving water, dilution of the heated effluent by river flow appeared to be adequate as no water temperature increases were recorded at downstream sites.

Provincial Water Quality Objectives of the Ministry of the Environment pertinent to dissolved oxygen are summarized below.

For warm water biota (fish species including pike, pickerel, bass), dissolved oxygen concentrations should at no time be less than the following values.

<u>TEMPERATURE °C</u>	<u>% SATURATION</u>	<u>mg/L</u>
0	47	7
5	47	6
10	47	5
15	47	5
20	47	4
25	48	4

The typical distribution of oxygen in a river subjected to organic waste discharge (B.O.D.), is expressed as a steady decline of oxygen below the discharge point to a zone of maximum oxygen reduction where dissolved oxygen concentrations reach minimum values. Following biological oxidation of the organic waste, a zone of recovery occurs and increasing oxygen concentrations, supplied by turbulence, exchange with the atmosphere and photosynthesis can be measured.

The dissolved oxygen concentrations measured 2 m from the bottom are summarized in Table 3 and are better suited for discussion than the profiles in Figure A.

In the Sturgeon River, the initial stage of dissolved oxygen sag downstream of the Mill outfalls (station 3, Figure 2) and the sewage treatment plant (station 5) was apparent. Minimum dissolved oxygen readings were found at station 7 near the mouth of the river with concentrations usually recovering at station 8, the dredged channel into Lake Nipissing. On two occasions, June 26 and August 9, dissolved oxygen concentrations at station 8 (6.0 and 2.8 mg/L) were significantly lower than in the river where concentrations were above 7.3 and 4.2 mg/L respectively.

Because the Lake Nipissing station was situated in the dredged boat channel through which the main flow of the Sturgeon River was directed, it was initially suspected that the low dissolved oxygen concentrations found were an extension of the oxygen sag zone. However, determinations of oxygen farther out into Lake Nipissing away from the influence of the Sturgeon River revealed similar reduced oxygen concentrations, particularly on August 9 when extremely low levels of oxygen (2.8 mg/L) were measured.

These low concentrations of dissolved oxygen in Lake Nipissing were measured during periods of still, warm and sunny weather, and the oxygen depletion recorded was attributed to the high oxygen demand of the densely vegetated, shallow, near-shore waters and the deep organic sediments.

It appears that oxygenation by wind turbulence and exchange with the atmosphere (expressed in higher June 24 and August 12 oxygen readings at station 8, than at the river mouth) are the prime sources for dissolved oxygen in the weedy, shallow portion of Lake Nipissing off the mouth of the Sturgeon River.

The distribution of dissolved oxygen along the Sturgeon River shows that a sag pattern existed; however, dissolved oxygen concentrations in the river generally remained within the water quality objectives for warm water fisheries during the survey.

The presence of generally favourable oxygen concentrations in the river despite the oxygen sag could be due to either

of two reasons:

- (1) The B.O.D. loading to the river during most of the sampling period may not have been high enough to result in oxygen depletion below the 4 mg/L level.
- (2) There was not sufficient distance of river to allow full manifestation of the oxygen demand. There was no extension of the oxygen sag zone into the lake because the Sturgeon River inflow to Lake Nipissing was easily dissipated by wave action and currents in the lake.

Secchi disc visibility is a measure of water clarity and is determined by lowering a black and white metal plate into the water until it disappears from view.

Measurements of Secchi disc visibility (Figure 4) leave no doubt regarding the effect of the Mill effluents on water clarity of the Sturgeon River. Secchi disc visibility downstream of Abitibi Forest Products (1. - 1.75 m) was approximately half that of the upstream sites (2.5 - 3.5 m) except on June 26 when Mill discharges were greatly reduced. On this date downstream Secchi disc visibilities were only 0.5 m less than those of the upstream stations which had Secchi disc visibilities of 3 m.

Reduced water clarity below the Mill outfalls was likely due to the addition of the turbid effluents resulting in increased suspended solids, organics and an intensification of water colour.

2. Bacteriological Water Quality

Four kinds of "indicator" bacteria: total coliform, fecal coliform, fecal streptococcus bacteria, and Pseudomonas aeruginosa are all indigenous to man and other warm-blooded animals, and are found in the colon and feces in tremendous numbers. Many diseases common to man can be transmitted by feces; consequently, the probability of occurrence of bacterial diseases is highest in areas where the water is contaminated with fecal material.

The density of these indicator bacteria in water will vary considerably between samples taken at the same station, or at different stations on a river, or if taken at different times, and so the assessment of water quality cannot be determined accurately from a single water sample.

Many samples taken at several river stations over an extended period of time are required.

The large amount of data from a multi-station extended duration survey must be reduced statistically in order that the results may be interpreted.

Statistical reduction involves the calculation of a geometric mean (the most appropriate central value) and variance for each of the "indicator" bacteria at every sampling station. Statistically significant variations in the bacterial densities between stations, or groups of stations, are determined by a One-Way Analysis of Variance and Bartlett's Test of Homogeneity. In this way, the data from each station are tested against those of every other station until all sampling stations

with similar geometric mean densities are separated into groups (Group A, B...).

In the presentation of evaluated data, the group results and those for individual stations are identified by different stippling on a summary map; for example, Figure 5. Within each stippled area, the group geometric mean is applicable for each type of bacteria unless otherwise indicated by individual station values; for example, station 1, Figure 5. The areas of better or worse bacterial densities are defined by the group geometric mean densities, and so, any inputs of bacterial contamination, and the area they affect can be identified.

In June and August 1977, the bacteriological water quality of the river above the dam at Sturgeon Falls was good. Below the dam the water quality of the river was poor as bacterial levels generally exceeded the Ministry of the Environment (M.O.E.) Recreational Criteria for total body contact which state:

"Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform, (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively in a series of at least ten samples per month including samples collected during weekend periods".

There are no specific criteria for Pseudomonas aeruginosa; but it is considered to be an opportunistic pathogen which may cause ear and eye infection in bathers. For this reason

it is an undesirable bacterium in recreational waters.

In June, the geometric mean bacterial densities for the river above the dam (at the falls) were within the M.O.E. Recreational Criteria with the exception of fecal streptococcus. The bacterial levels were 206 TC, 11 FC, 51 FS and 2 PA per 100 ml (Group A, Figure 5). Below the dam the bacterial levels rose to 2,800 TC, 307 FC, 995 FS and 31 PA per 100 ml, thereby exceeding the M.O.E. Recreational Criteria for all parameters (Group B, Figure 5). The increased levels of fecal coliforms and Pseudomonas aeruginosa indicated a large source of fecal bacteria in the vicinity of Sturgeon Falls.

Very poor water quality was found at the main outfall from Abitibi (Station 1, Figure 3). The bacterial densities at this location were 330,000 TC, 168,000 FC, 201,000 FS and 143 PA per 100 ml which exceeded the levels of bacteria found everywhere else on the river. Other outfalls from or near the Abitibi plant (Stations 2, 3 and 4) had low densities of total coliforms which ranged from 26 - 680 TC per 100 ml and a low fecal coliform level of 2 FC per 100 ml at Station 3.

Further downstream the outfall from the sewage treatment plant (STP), Station 14, had low bacterial densities of 5 TC, 1 FC, 4 FS and 1 PA per 100 ml. These low bacterial densities were the result of chlorination of the sewage plant effluent.

An inflowing stream (Station 17) had elevated total coliform levels of 14,000 TC per 100 ml. Inflowing streams often have higher bacterial densities than the receiving waters as they may carry materials washed from soil, decaying matter and, if present, animal and human wastes into the river.

The bacterial densities were reduced where the Sturgeon River flowed into Lake Nipissing. At Station 35, bacterial densities of 243 TC, 11 FC, 93 FS and 2 PA per 100 ml were found and the reduction in the previous high bacterial densities was likely due to dilution of the river water in the lake.

In August, the geometric mean bacterial densities for the river above the dam were 130 TC, 4 FC, 39 FS and 1 PA per 100 ml (Group A, Figure 6). This level of water quality would be considered satisfactory for river water, however, the fecal streptococcus levels exceeded the M.O.E. recreational criteria, and indicated a low level of contamination probably of animal or of stormwater origin. The lower part of the river (downstream of the Mill outfalls) showed increased bacterial densities of 815 TC, 48 FC, 445 FS and 18 PA per 100 ml (Group B, Figure 6). The only large input of bacteria in this location was from the main outfall from Abitibi (Station 1, Figure 3) which discharged water containing 119,000 TC, 4,900 FC, 10,000 FS and 5,500 PA per 100 ml. Smaller densities of the fecal indicator bacteria were found in the other outfalls near the Abitibi plant; bacterial densities 277 TC and 6 PA per 100 ml; 63 TC, 12 FC and 7 PA per 100 ml; and 11 TC, 108 FS and 3 PA per 100 ml were found at Stations 2, 3 and 4 respectively.

Further downstream the bacterial densities rose to 4,800 TC, 48 FC, 445 FS and 82 PA per 100 ml (Group C, Figure 6).

The sewage treatment plant outfall (Station 14) contained 15 TC, 1 FC, 24 FS and 4 PA per 100 ml.

As in the spring, the bacterial densities were reduced where the Sturgeon River flowed into Lake Nipissing. At Station 35, the densities of total coliforms and Pseudomonas aeruginosa were reduced by dilution in the lakewater to 952 TC and 2 PA per 100 ml respectively.

Geometric mean densities of fecal coliforms, fecal streptococcus and Pseudomonas aeruginosa were calculated for each sampling location on the river and displayed in order, following the downstream flow of the river. The large input of bacteria from the Abitibi outfall was very obvious in both spring and summer (Figures 7 and 8). In the summer, P. aeruginosa and fecal streptococci appeared to grow in the river. For example, the densities of P. aeruginosa increased progressively downstream, from Station 5 to Station 13, but slowly decreased thereafter until the river discharged into Lake Nipissing (Station 35) where the decrease was more rapid (Figure 8).

Heterotrophic bacteria require a source of organic nutrients to thrive and for this reason are found in the greatest numbers in nutrient rich waters. Their presence can be an indication of the input of organic nutrients to a receiving system.

In June, the geometric mean density of aerobic heterotrophic bacteria upstream from Sturgeon Falls (Station 37 and 40, Figure 3) was 935 HB per 1.0 ml, whereas downstream, the levels of heterotrophic bacteria rose significantly to 7,730 HB per 1.0 ml at Station 6 and to 58,600 HB per 1.0 ml further downstream at Stations 20 and 28 (Table 5). The large progressive increases in heterotrophic bacterial densities below the falls may indicate growth of bacteria in response to the higher nutrient levels in these waters.

During August, the geometric mean density of the aerobic heterotrophic bacteria was 1,980 HB per ml upstream from Sturgeon Falls which increased to 15,100 HB per ml at Station 6. Further down the river heterotrophic bacterial densities rose to 67,500 HB per ml. In agreement with the June survey, the progressively higher heterotrophic densities downstream indicated increased nutrient levels and possibly subsequent growth of bacteria in the river (Table 5).

The evidence of fecal pollution obtained from the bacteriological surveys made it necessary to confirm the identity of some of the Pseudomonas aeruginosa and fecal coliforms isolated from the river. Between 96-98% of the Pseudomonas aeruginosa colonies were confirmed as Pseudomonas aeruginosa. This high rate of confirmation of Pseudomonas aeruginosa applied to bacteria isolated from the Abitibi outfalls and from the river (Table 6).

All of the fecal coliforms isolated above the dam at the falls were identified as Escherichia coli.

The types of fecal coliforms isolated from the lower section of the river (Station 26) were also identified. The results showed that 13% were Escherichia coli, a bacterium that is found in feces. Klebsiella pneumoniae made up 55% of the fecal coliforms (Table 7). This bacterium is an opportunistic pathogen to humans. It is found in relatively low numbers in feces but has been found in high numbers in pulp-mill waste and in unchlorinated effluent from sewage treatment plants.

Fecal coliforms isolated from the river downstream of the Mill resembled those that were isolated from the Mill outfall. The types of fecal coliforms isolated from the river upstream of the Mill were not similar to those isolated below the Mill. This information further confirmed the conclusion made from the quantitative data that the source of the pollution in the river was the Abitibi Forest Products Mill.

The dominant fecal coliform from the Abitibi plant was K. pneumoniae, a bacterium which is recognized as an opportunistic pathogen potentially leading to respiratory and other infections. Low densities of K. pneumoniae are commonly found in nature. They are also found in the bark of trees from where they could be carried into wood-processing plants. This opportunistic pathogenic bacterium has been isolated before from pulp-mill effluents (Huntley et al, 1976).

Another opportunistic pathogenic bacterium, P. aeruginosa, was found in great numbers in the Abitibi plant effluent. P. aeruginosa has been shown to cause ear and eye infection in bathers and is considered an undesirable bacterium in recreational waters (Sayfried & Fraser, 1977).

The primary source of P. aeruginosa is thought to be sewage or nutrient-rich contaminated water.

The source of P. aeruginosa in the Abitibi Mill may have had either origin. Although, the sewer lines containing sanitary waste were separated from process waste sewers, both lines were housed within the same open sewer case in some parts of the Mill. Cross contamination of the process waste from leaks in the sanitary lines was considered a possibility.

The source of P. aeruginosa in the Abitibi plant may also have been river water brought into the plant for processing purposes. The initially low number of P. aeruginosa in the upstream waters could increase due to growth on the nutrients extracted from the wood during the processing. It was thought that the large number of P. aeruginosa in the effluent came about through growth in the nutrient-rich processing wastes.

A similar argument can be used to show that total coliform and fecal streptococci organisms were brought into the Mill in river water and subsequently grew in the nutrient-rich industrial wastes.

E. coli was discharged into the river from the Abitibi Mill at an approximate concentration of 180/100 ml. It is considered that the sole source of E. coli in the environment is feces or sewage-contaminated water. Either the process wastes were contaminated directly by sewage, or E. coli, 4/100 ml, was brought into the Mill in river water and the increase in numbers resulted from growth in the nutrient rich wood processing wastes.

The growth of E. coli in the environment is a rare and unexpected occurrence.

An alternative hypothesis for the growth of bacteria in the Mill, is the possibility that the bacteria grew on or under the bark of trees and wood chips during storage in the river or in the Mill prior to pulping. The increase in numbers would be brought about by mechanical disintegration of the bacterial growths. In support of the bacterial growth hypothesis, it has been observed that numbers of total coliforms and K. pneumoniae increased markedly during the secondary treatment of pulp-mill wastewater. It has also been observed that K. pneumoniae was able to grow rapidly in sterile wastewater from a pulp-mill (Knittel, 1975).

The numbers of bacteria in the Sturgeon River increased with distance downstream of the Abitibi inputs. In August, maximum river concentrations for fecal coliforms, fecal streptococci and P. aeruginosa were reached between bacteriological sampling locations 6 and 12 (Figure 8). Initially, the increases were attributed to mixing, and the growth of bacteria in the river. However, water chemistry samples indicated that B.O.D. (a measure of material available for bacterial oxidation) was not high; therefore, the bacterial growth phenomenon might better have been explained by the process of regrowth.

Injured bacteria are unable to grow in the selective media used for water microbiology. As the injured portion of a population of bacteria recover in the river, the number of colonies which appear on the selective medium increases without real bacterial growth in the river water. This

phenomenon mimics growth and is called "regrowth". The injured bacteria in the river population could be heat-injured and may be produced by the hot process used in the wood-processing plant.

Effect of the Sewage Treatment Plant on the Water Quality of the River

It can be seen that following the downstream increases in bacterial numbers in the river, the maximum densities of bacteria and so the maximum of water quality deterioration, was achieved before the sewage treatment plant outfall (Station 14) was reached (Figure 8). The sewage treatment plant did not appear to have an effect on the river water quality, however, an effect could have been obscured by the poor water quality of the river at the point of effluent discharge. This is considered unlikely since the reported operating record of the STP was good, and the quality of disinfected effluent samples was similar to samples taken in this survey (M.O.E. 1976).

3. Sediment Composition and Invertebrate Presence

Table 5 summarizes observations, impressions and macro-invertebrate collections during the sediment dredging survey. Results showed deterioration of environmental quality downstream of the Abitibi Forest Products outfalls.

Sediments obtained downstream of the Mill all had shredded wheat-like fiber particles deposited on them and incorporated within. Larger chunks and chips of wood were found in the slow moving sections of the Sturgeon River primarily at the

sampling stations nearest the Mill outfalls. The zone of greatest influence, with regard to fiber and wood chip deposition, extended from chemical sampling location 3, (Figure 2) through Minnehaha Bay below the Highway 17 bridge to station 4, located just upstream of the sewage treatment plant outfall.

Foul odours, the product of bacterial action on organic material under anaerobic (no oxygen) conditions, characterized the sediments down to site 4. By far the worst sediment conditions were found in the site 3 series of samples. Location 3a, the first bay on the east side of the river upstream of the Highway 17 bridge is a depository for winter snow removal operations in the Town of Sturgeon Falls. The large assortment of debris associated with snow removal operations, and the wood chunks and particles from the Mill deposited by the river current, provided a substrate for bacterial generation of volatile gas which constantly bubbled to the surface.

Site 3d, downstream of the Highway 17 bridge where the fast flowing river widens into Minnehaha Bay, was a settling area for wood fiber and chunks.

At all remaining downstream sampling locations, sediment samples were composed largely of natural materials ranging from granitic pebbles through clay, sand and organic ooze. Although wood fiber was present, it was not there in quantities sufficient to mask the character of the natural bottom nor did it give rise to the generation of gases or the production of unpleasant odours.

From the appearance of the sediments in the Sturgeon River, it appears that there is sufficient movement of water with adequate velocity to provide a scouring of the river bottom, except in the backwater bays nearest the Mill where most of the wood debris was found to have settled.

Sediment Biology

In the evaluation of sediment quality, the presence, numbers and types of living organisms inhabiting the sediments can be used as an indication of environmental quality. When contaminants are introduced to a natural community, the standing crop (number) and numbers of taxa (different types of organisms) can change drastically.

Diversity indices are a statistical tool for measuring the quality of the environment and the effect of stress on the structure of a community of macroinvertebrates. The use of a diversity index is based on the generally observed phenomenon that relatively undisturbed environments support communities having a large number of species with no individual species present in overwhelming abundance (high diversity). Many forms of stress induced by the introduction of foreign substances or contaminants tend to reduce community diversity by making the environment unsuitable for some species or by giving other species a competitive advantage.

In unpolluted waters, diversity indices as calculated by the Shannon-Weaver function, generally range between 3 and 4, whereas in polluted water the diversity index is usually below 1, (EPA 1973). Where taxonomic classification is

not rigorous (down to species level) a lower maximum index value is expected for unpolluted conditions.

As shown in Table 8, the greatest variety of macroinvertebrates was found at stations S_1 and S_2 (Figure 2) located upstream of the Mill. Eight different types of invertebrates were found at both stations resulting in diversity index values of 2.63 and 2.82 respectively.

In accord with observed sediment habitat quality deterioration, macroinvertebrate communities downstream of the Mill discharge area were found to be depressed. Diversity indices, from sampling locations 3 to 7 (Figure 2) were low ranging between a minimum of 0.54 at station 7 to a maximum of 1.35 at station 6.

At stations 8 and S_3 in Lake Nipissing an improvement in invertebrate variety was observed as a combined diversity index of 2.86 was calculated for the eight types of organisms found.

By way of comparison, macroinvertebrate diversity indices in upstream and Lake Nipissing sampling locations were significantly higher than in the river downstream of the Mill indicating a reduced suitability of the sediment and water environment for the support of sediment-based life in the stretch of the river below the Mill outfalls.

SUMMARY - CONCLUSIONS

There was deterioration of water quality downstream of the Abitibi Forest Products Mill at Sturgeon Falls.

The aesthetic condition of the lower Sturgeon River was affected in the following ways:

- Mill outfalls produced turbidity plumes which contributed to downstream reduction of water clarity.
- The discharge of wood fiber particles resulted in the visible suspension of the particles in the area below the discharges and the settling of the particles on downstream sediments.
- Slimy, cotton-wool-like sewage fungus grew and broke away from the area below the Mill outfalls and was carried downstream by the river currents in pieces and clumps.
- Flammable gases were generated in the sediment of the first slow flow zone below the Mill discharges and the gases constantly bubbled to the surface.

Monitoring of chemical water quality above and below the Mill outfalls revealed increases in the concentrations of parameters associated with the Abitibi Mill effluents.

These included:

conductivity	suspended and dissolved solids
colour	tannins and lignins
biochemical oxygen demand	organic carbon
chemical oxygen demand	phenols
total Kjeldahl nitrogen	

Although increased quantities of the above mentioned parameters were found downstream of the Mill, individual concentrations measured during the survey would not usually be considered to be problematic when encountered in surface waters. Only the phenolics, which averaged 27 ug/L, greatly exceeded the 1 ug/L concentration permitted by the Ministry of the Environment Criteria for drinking water supplies. In addition, the concentrations of phenolics were within the range that could induce the tainting of fish flesh; but, no reports of tainting are on record.

Although individual downstream concentrations of the carbonaceous components (colour, C.O.D., tannins and lignins, organic carbon, phenols) were not considered to be problematic, the carbonaceous compounds originating in wood processing wastes were likely an important nutrient source for the growth of nuisance organisms like sewage fungus and bacteria when coupled with additions of organic nitrogen (total Kjeldahl nitrogen).

A trend of declining dissolved oxygen concentrations was observed downstream from the Mill to the mouth of the river. However, the concentrations measured remained within the range considered to be suitable for the support of warm water fisheries.

A significant reduction of water clarity was measured downstream of the Mill.

The bacteriological water quality of the Sturgeon River above the Abitibi Forest Products Mill was good. Below the Mill the bacteriological water quality was poor with bacterial levels generally exceeding the recreational criteria for total body contact.

The main input of fecal bacteria was traced to the Abitibi Forest Products Mill. The zone of influence of bacterial pollution extended to the mouth of the river.

Three well defined problems resulted from Mill pollution inputs:

1. Discharge from the Mill of some bacteria of fecal origin.
2. Discharge of the opportunistic pathogens K. pneumoniae and P. aeruginosa.
3. Masking of other possible sources of bacterial pollution to the river downstream of the Mill.

The sewage treatment plant at Sturgeon Falls discharged a chlorinated effluent with relatively few viable fecal bacteria having no measurable effect on the river.

Deterioration of environmental quality downstream of the Abitibi Forest Products outfalls was indicated from sediment samples. Chunks and chips of wood were found in the slow moving sections of the river nearest the Mill outfalls. Farther downstream, wood fibers were deposited on and incorporated within the bottom muds, but not in sufficient quantities to mask the character of the natural bottom.

A reduced suitability for the support of sediment-based living organisms downstream of the Mill was indicated by the numbers and types of macro-invertebrates encountered.

RECOMMENDATIONS

Whereas the existence of degraded aesthetic, chemical and bacteriological water quality along with stressed sediment habitat for macroinvertebrates downstream of the Abitibi Forest Products Mill were attributed to the past or present activities of the Mill, the following recommendations specific to the operation of the Mill are submitted:

- The discharge of particulate matter resulting in the visible suspension of wood fiber particles below the effluent discharge area and the deposition of the fibers on downstream sediments should be curtailed.
- In light of the fact that a history of profuse growths of the cotton-wool-like slime resulting in impairment of downstream recreational use does exist, and the fact that the slime growth is associated with the Mill effluent, the origin, cause and conditions promoting nuisance growths should be investigated so that under favourable environmental circumstances for extensive growth of the slime in the river, the impact on downstream use can be minimized.
- The bubbling of volatile gases in the first backwater bay downstream of the Falls and the effluent discharge area (sediment sampling location 3a, Figure 2) is undesirable and is the result of chemical reducing conditions on the settled wood chunks and fibers along with debris from the snow dumping practices of the Town of Sturgeon Falls. Since there does not appear to be sufficient flow in

this part of the river to scour the sediment, mechanical removal of debris is suggested.

- Except for phenols, which upon combination with chlorine can lead to taste and odour problems in drinking water and tainting of fish flesh, other chemical parameters investigated did not exhibit significant increases downstream of the Mill outfalls. However, investigation into the reduction of downstream concentrations of additional parameters is warranted. In particular management of B.O.D. discharges should ensure the maintenance of adequate dissolved oxygen concentrations downstream of the Mill and the contributions of the various organic components present in the process wastes to the nuisance growth of slimes should be investigated.
- The existence of a pattern of steadily declining dissolved oxygen concentrations downstream of the Mill outfalls and the presence of what were considered near oxygen stress conditions near the river mouth on two occasions during the survey were an indication that oxygen problems may occur. In order to ensure that dissolved oxygen levels in the river remain favourable for the support of normal aquatic life, the dissolved oxygen regime in the river under various waste loading, flow and temperature conditions should be evaluated and modelled so that waste discharges can be managed to achieve favourable dissolved oxygen levels at all times.

- Because water clarity is an important component of water quality, a positive effect on aesthetics, light penetration, biotic habitat and ultimately, fisheries production could be achieved by reducing the impact of turbidity causing constituents and coloured substances on the clarity of the Lower Sturgeon River. It is recommended that an investigation of the substances causing reduced water clarity be undertaken with a view to the eventual reduction of the effect of the substances on light penetration.
- Because the Ministry of the Environment recreational use bacteriological criteria for total body contact (swimming) were consistently exceeded in samples downstream of the Mill and because the opportunistic pathogens Pseudomonas aeruginosa and Klebsiella pneumoniae were isolated in moderate to high numbers, the use of the lower Sturgeon River for total body recreation should be openly discouraged pending evaluation of the public health significance and the risk of infection from the bacteria found.
- Investigations should be undertaken to establish the origin of fecal bacteria in the Abitibi Forest Products process wastes and studies initiated to examine the conditions available for bacterial growth in order that a solution be found for the reduction and control of bacterial emissions.
- Since the area of major sediment impairment of macro-invertebrate habitat by wood chunks, chips and fiber appeared to be restricted to slow flow deposition zones between the Mill discharge area and the large bay (Minnehaha)

downstream of the Highway 17 bridge, mapping of the area of sediment under the influence of wood debris and formulation of a mechanical rehabilitation program is suggested.

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ADDENDUM

Since the completion of the 1977 water quality survey, the following activities pertinent to the recommendations of this report and the Control Order against the Abitibi Forest Products Mill at Sturgeon Falls have been undertaken:

1. Source of Bacteria

After the discovery of high densities of bacteria in the Lower Sturgeon River, an in-plant survey of process waste sewers was initiated. Samples obtained from process sewers revealed the presence of E. coli and K. pneumoniae suggesting cross contamination from sanitary wastes.

The sewers containing sanitary wastes were tested with dyes for cross connections to the process waste sewers but, no visible leaks were found. However, because of the condition of the sewers housing the process and sanitary waste conduits, the dye test was not considered to be definitive.

A subsequent in-plant sampling in August and October 1978 confirmed the presence of large numbers of K. pneumoniae, E. coli, P. aeruginosa and fecal streptococci.

Additional work to detect the origin of these bacteria within the plant is planned.

2. Public Health Significance

The question of the public health significance of the types and quantities of bacteria found in the Lower Sturgeon River has been addressed through the Ontario Ministry of Health and the North Bay and District Health Unit.

The Ministry of Health comments are stated below:

"Klebsiella pneumoniae and Pseudomonas aeruginosa are considered to be ubiquitous inhabitants of rivers, lakes, bathing waters and soil. They are opportunistic human pathogens which may be spread by water. While Klebsiella may also be found in tree barks or in certain plants, Pseudomonas aeruginosa may be present in soils or water contaminated with human or animal wastes. Klebsiella species are considered non-pathogenic to man with the exception of Klebsiella pneumoniae. Klebsiella pneumoniae multiplies in the aquatic environment under favourable temperatures with available nutrients such as paper mill effluents or untreated sewage.

Until the taxonomy of Klebsiella has been cleared, and each species has been properly identified for pathogenicity and public health importance, development of water quality standards for the presence of this organism in water may not be available in the foreseeable future.

The isolation of Pseudomonas aeruginosa and indicator organisms in significant concentrations below the Mill Outfall in the Sturgeon River should be regarded with concern. Precautions should be taken before permitting body contact recreation of susceptible populations in the river downstream".

The North Bay and District Health Unit have been aware of the problem of high coliform bacteria counts in the Lower Sturgeon River and have advised that:

"the area below the Mill and near the government dock has been placarded for unsafe counts for swimming for several years".....

"Klebsiella pneumoniae and Pseudomonas aeruginosa
.....are not considered pathogens, but are
"opportunistic" and considered as secondary invaders.
The possibility that these may cause infection in
bathers is not great and this is supported by the
low number of isolations obtained in local labora-
tories".

3. Dissolved Oxygen

During 1978, Beak Consultants Limited were hired by the
Abitibi Paper Company Limited to investigate the dissolved
oxygen regime of the Lower Sturgeon River under various
waste loading-river flow conditions. A waste assimilation
model designed to maintain dissolved oxygen concentrations
above the warm water fishery objectives has been presented.

APPENDIX

MILL EFFLUENT AND STURGEON RIVER FLOWS AS PROVIDED BY
ABITIBI FOREST PRODUCTS LIMITED STURGEON FALLS DIVISION

MILL EFFLUENT FLOWS M³ /DAY

<u>1977</u>	<u>B. LIQ.</u>	<u>CLEAN</u>	<u>CLAR</u>	<u>TOTAL</u>
June 24	2740	2201	14112	19053
26	----	2265	14112	16677
28	2366	2082	14976	19424
Aug. 9	2366	1960	14112	18438
12	2229	1960	14400	18589

STURGEON RIVER FLOWS - C.F.S.

(cubic feet/second)*

	<u>June, 1977</u>							<u>August, 1977</u>					
<u>Date</u>	23	24	25	26	27	28	29	8	9	10	11	12	13
<u>Time</u>													
09	1605	1860	2210	1620	2310	1590	2235	945	1050	1130	910	1080	1180
10	1605	1860	2210	1620	2310	1590	2235	945	970	1130	910	1030	1270
11	2130	1460	2210	1620	2310	2285	2145	865	1050	1130	910	1030	1270
12	2130	1460	2210	1590	1670	2285	2145	865	1050	1130	990	1030	1270
13	2130	1745	2185	1655	1395	2195	2145	865	1050	1130	990	1030	1270
14	1950	1745	2060	1745	1395	2195	1975	865	1050	1130	1080	1030	1270
15	1950	1745	2060	1745	1205	2195	1975	905	1050	1130	1080	1180	1220
16	1750	1790	2060	1700	1205	1925	1975	985	1050	1130	1180	1180	1210
17	1620	1645	1970	1700	1530	1770	1975	985	855	1130	1180	1180	1210
18	1620	1645	1875	1895	1530	1770	1975	985	855	1025	1180	1180	1210
19	1620	1645	1875	1895	1685	1770	1975	1050	855	1025	1180	1180	1050
20	1670	1645	1800	1895	1685	1965	1975	1050	915	1465	1180	1180	1050
21	1620	1645	1845	1895	1685	1965	1975	1050	915	1465	1180	1180	1050
22	1570	1740	1845	1895	1940	1965	1975	1050	915	1465	1165	1180	1050
23	1570	1760	1845	1920	1800	1965	2010	1050	915	1130	1165	1180	1050
24	1570	1790	1845	1600	1880	1975	2010	1050	1105	1130	1030	1180	1050
01	1625	1790	1965	1520	1880	1975	2010	1050	1260	1130	1030	1180	1050
02	1625	1790	1875	1600	1830	1965	2010	1050	1260	1050	1030	1180	1050
03	1625	1250	1845	1895	1830	1965	2010	1050	1260	1050	1030	1180	995
04	1625	1250	1875	1860	1830	1765	2010	1050	1070	1050	1030	1180	1035
05	1625	1250	1875	1860	1880	1765	2010	1050	1070	1050	1030	1180	1075
06	1625	1980	1825	1860	1880	1865	2330	1050	1070	1050	1030	1180	1075
07	1625	1980	1475	1860	1830	1980	2330	1050	1070	1050	1030	1180	1075
08	1625	1980	1475	1860	1830	1980	2230	1050	1070	910	1030	1180	1075

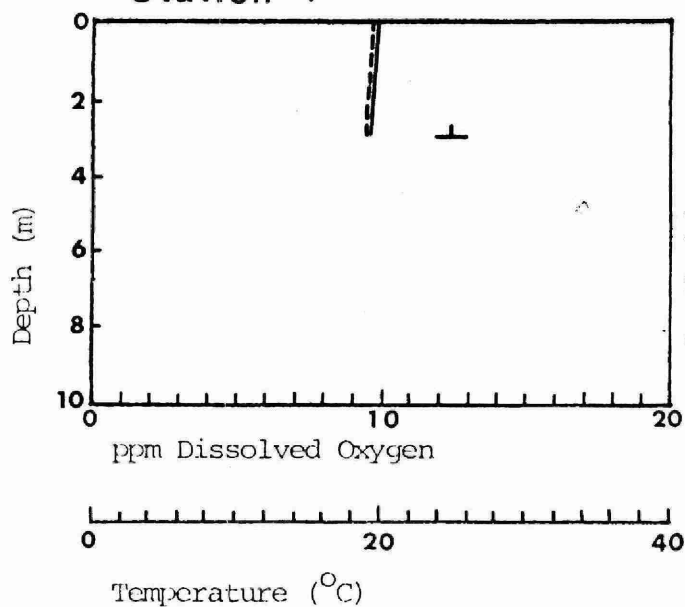
* To convert C.F.S. to m³/day multiply by 2445.

Dissolved Oxygen - Temperature Profiles

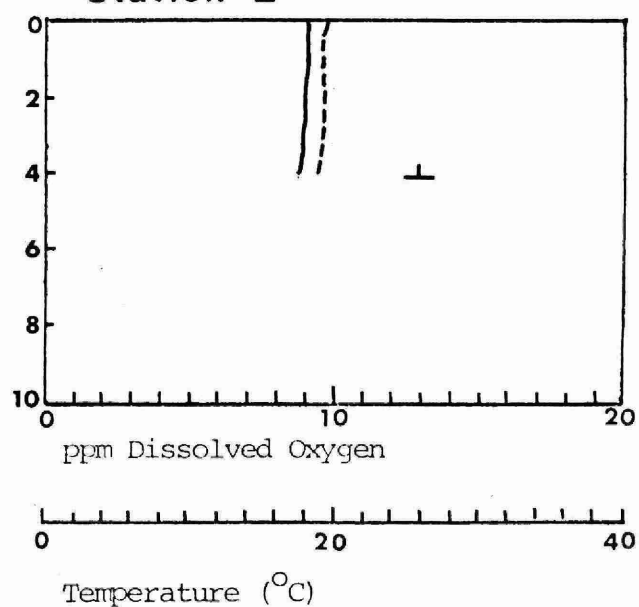
Sturgeon River

June 24 1977

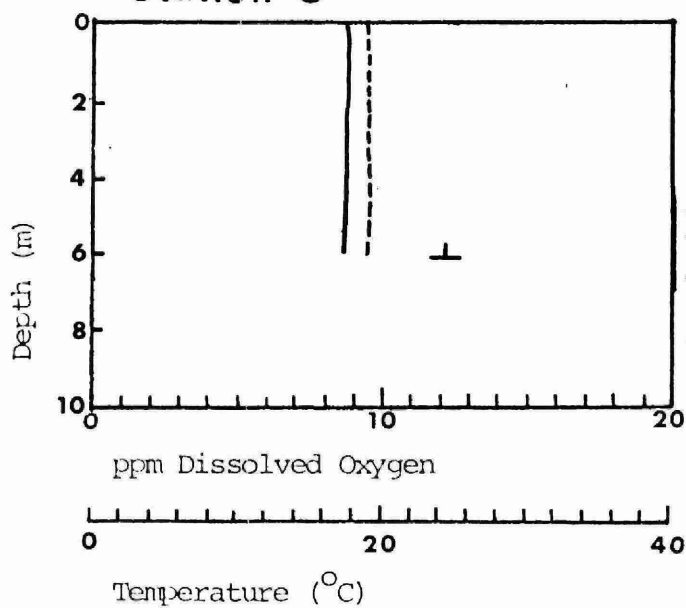
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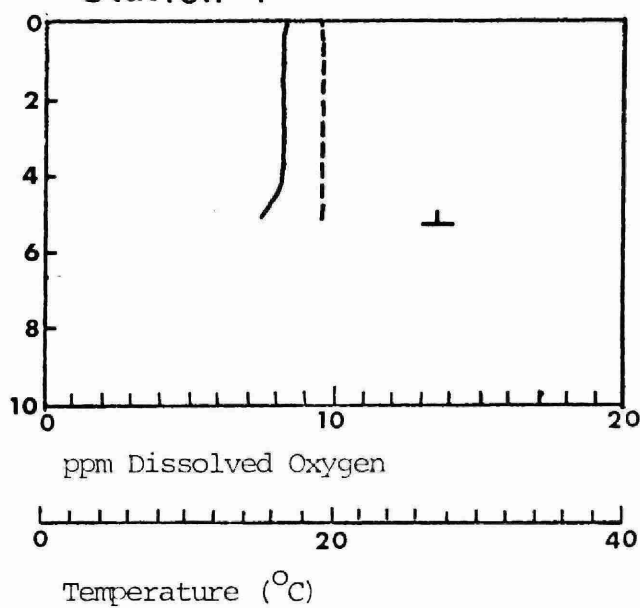
Station 2



Station 3



Station 4



— Dissolved Oxygen Curve
- - - Temperature Curve
└ Lake Bottom

Figure A1

Dissolved Oxygen - Temperature Profiles

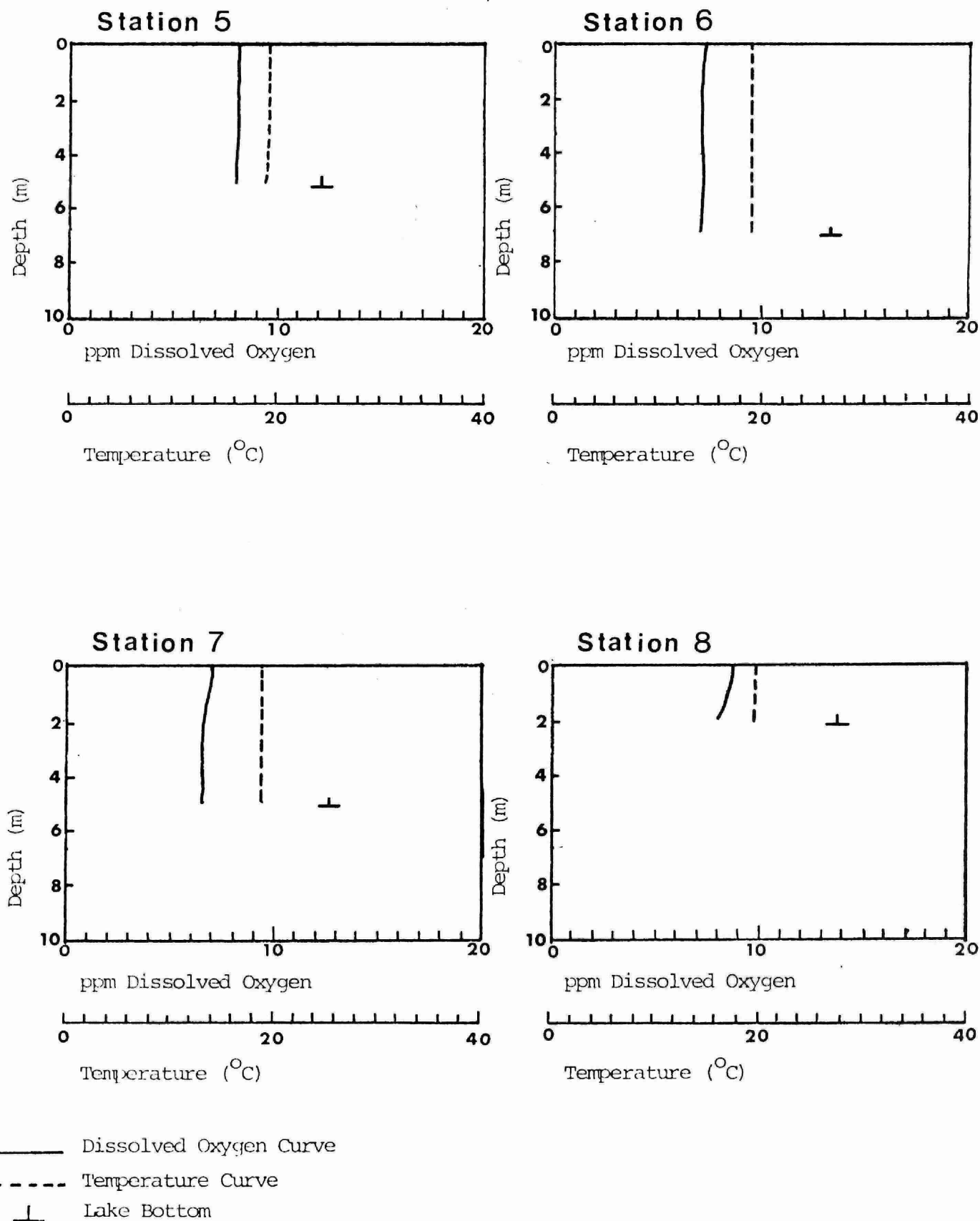
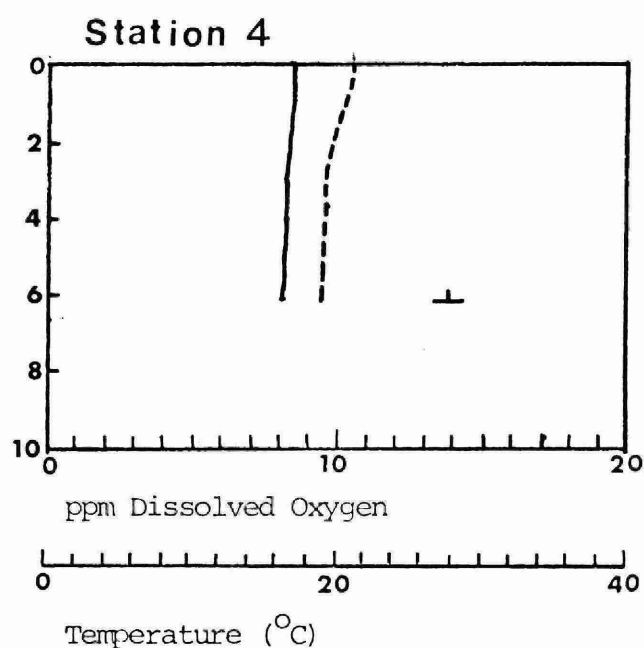
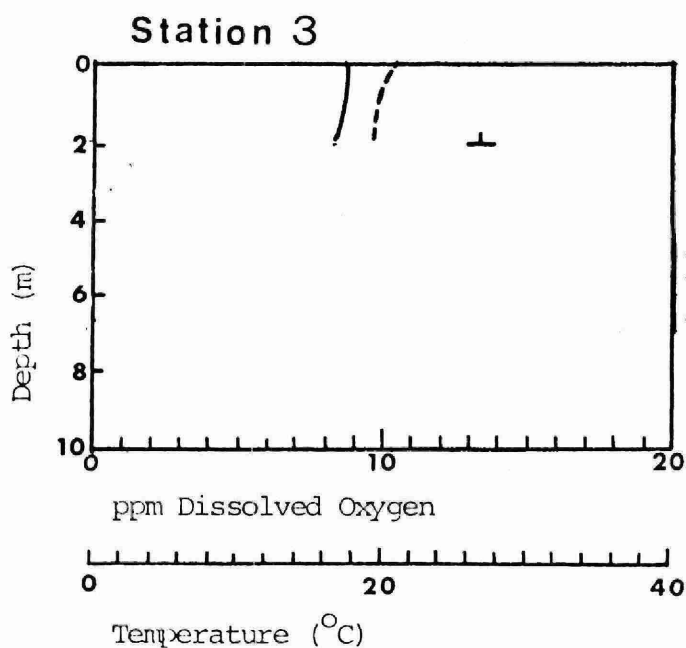
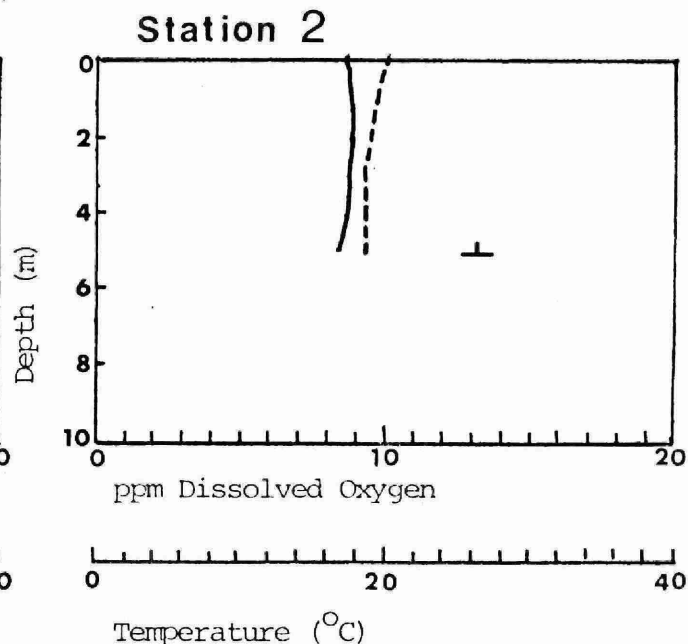
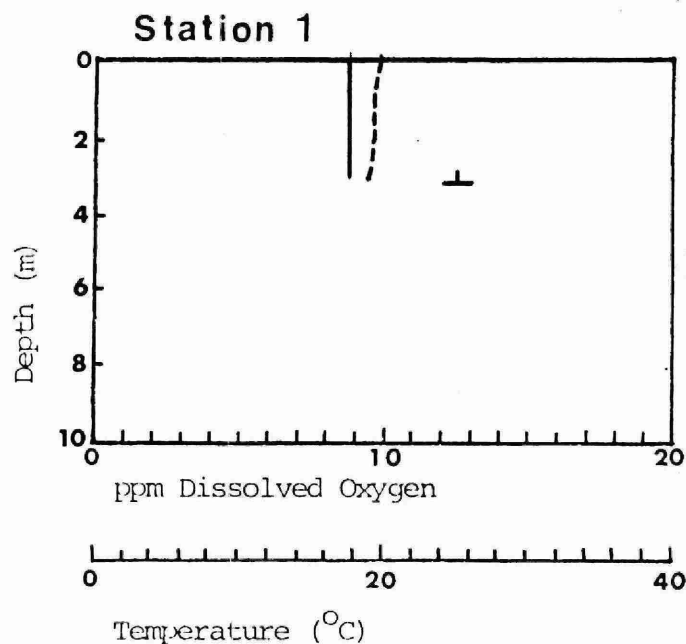


Figure A1b

Dissolved Oxygen - Temperature Profiles

Sturgeon River

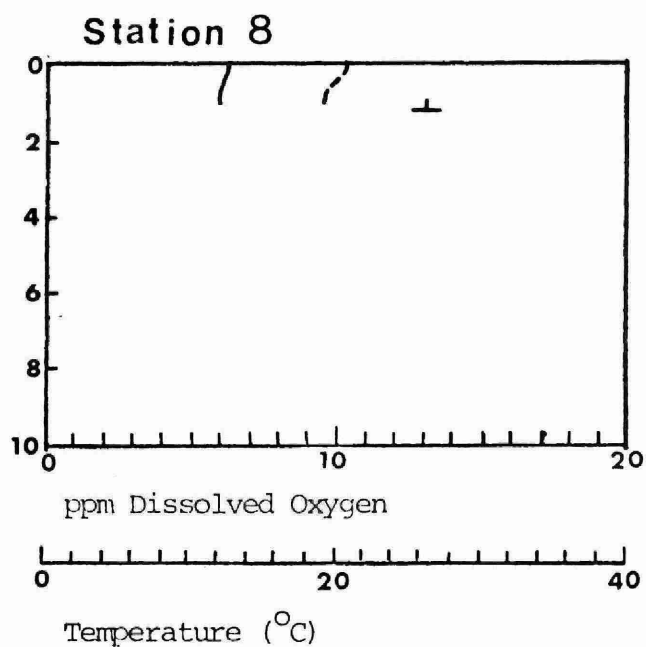
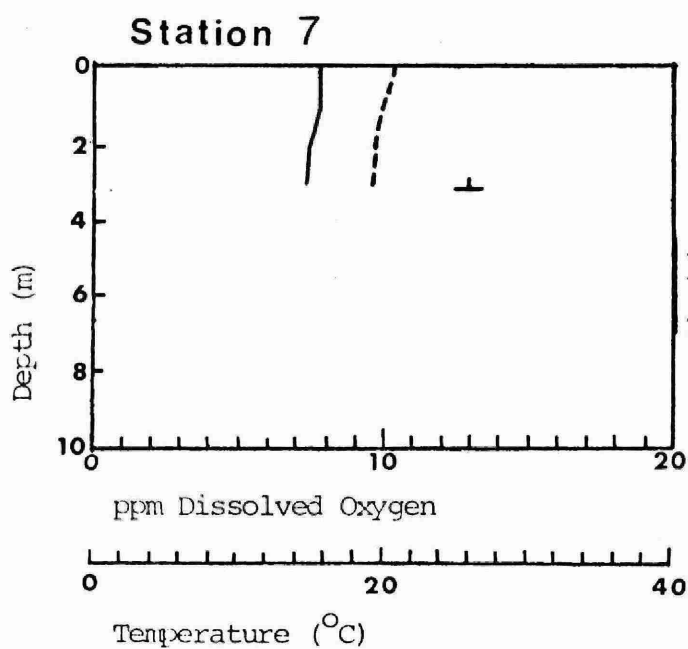
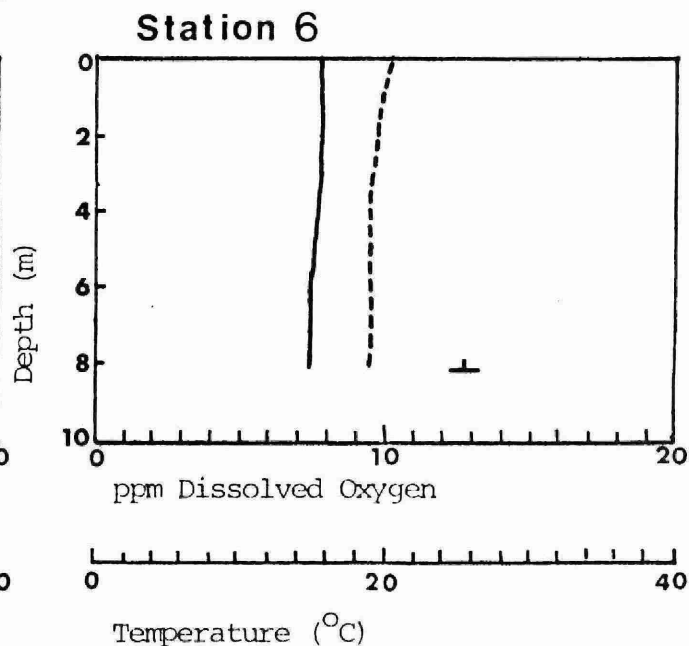
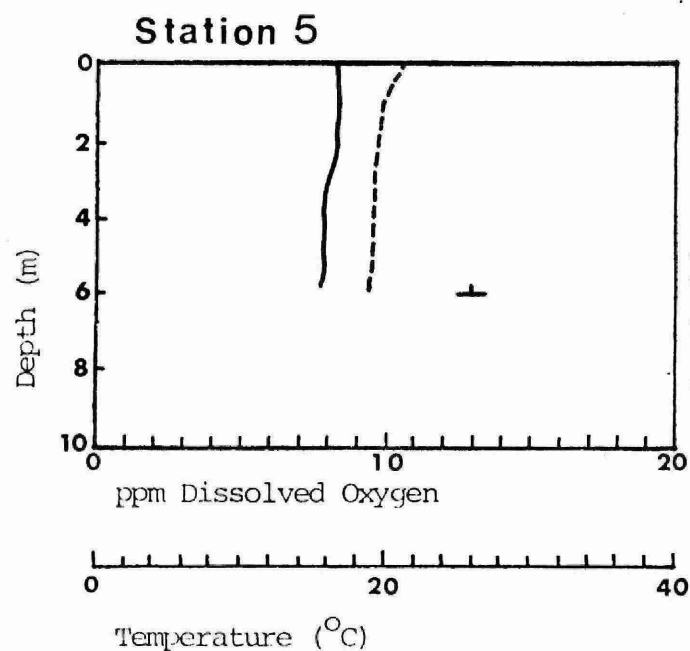
June 26 1977



— Dissolved Oxygen Curve
- - - Temperature Curve
└ Lake Bottom

Figure A2

Dissolved Oxygen - Temperature Profiles



— Dissolved Oxygen Curve
- - - Temperature Curve
┬ Lake Bottom

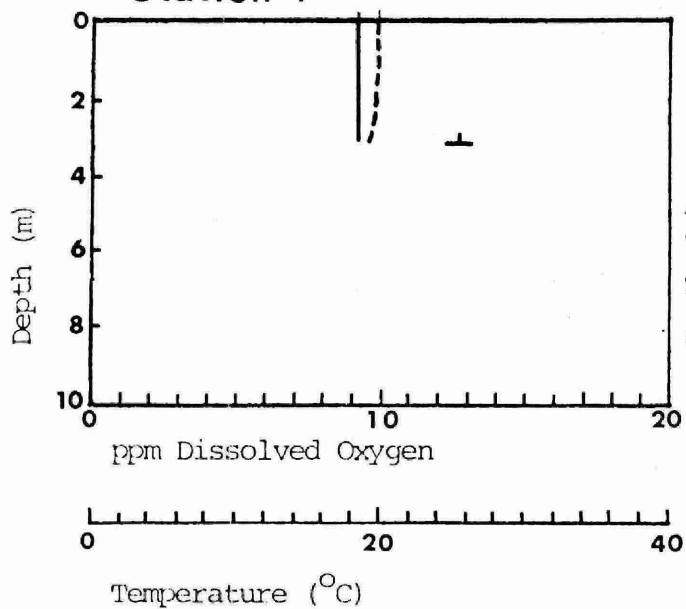
Figure A2b

Dissolved Oxygen - Temperature Profiles

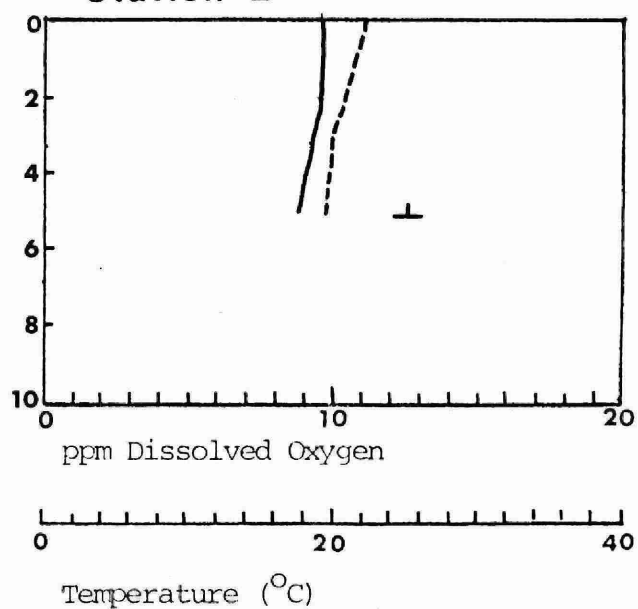
Sturgeon River

June 28 1977

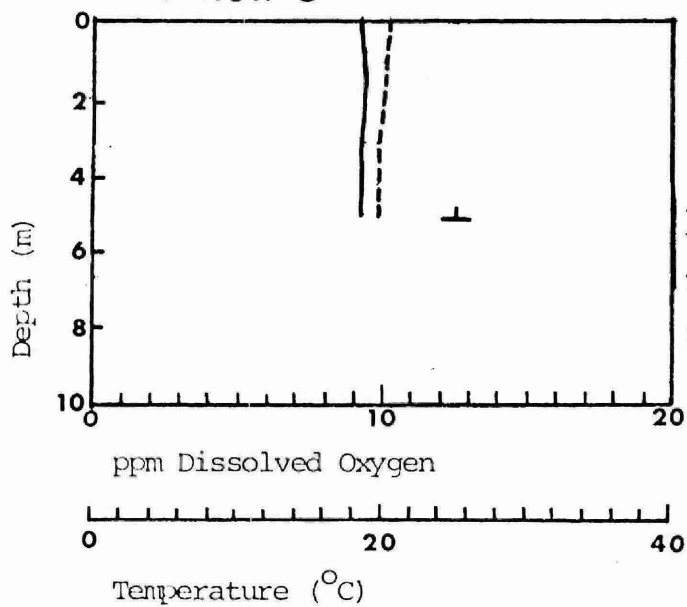
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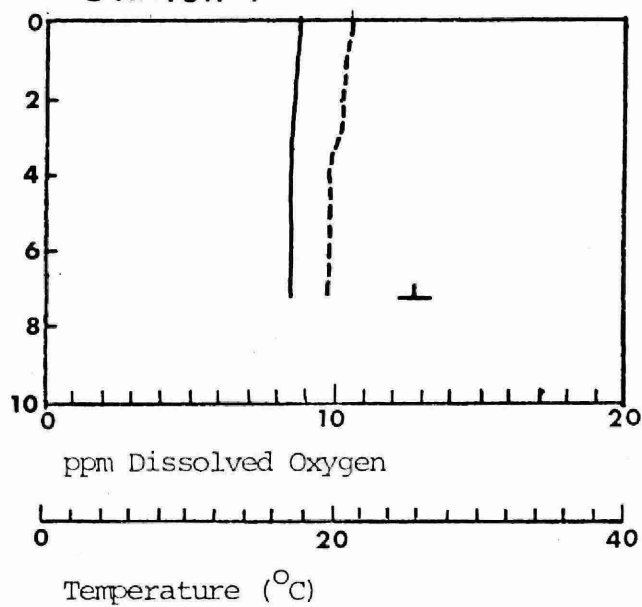
Station 2



Station 3



Station 4



— Dissolved Oxygen Curve
- - - Temperature Curve
└ Lake Bottom

Figure A3

Dissolved Oxygen - Temperature Profiles

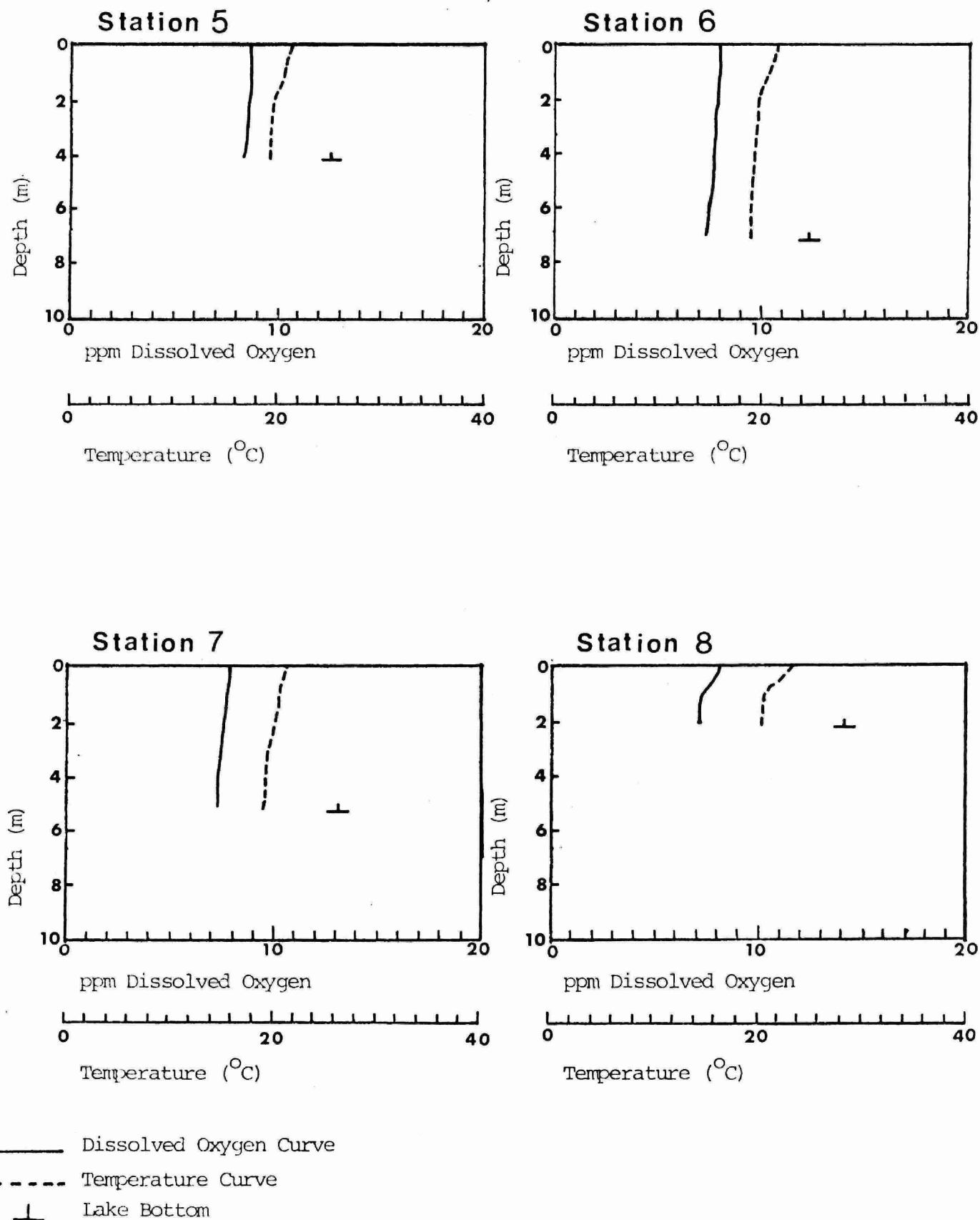
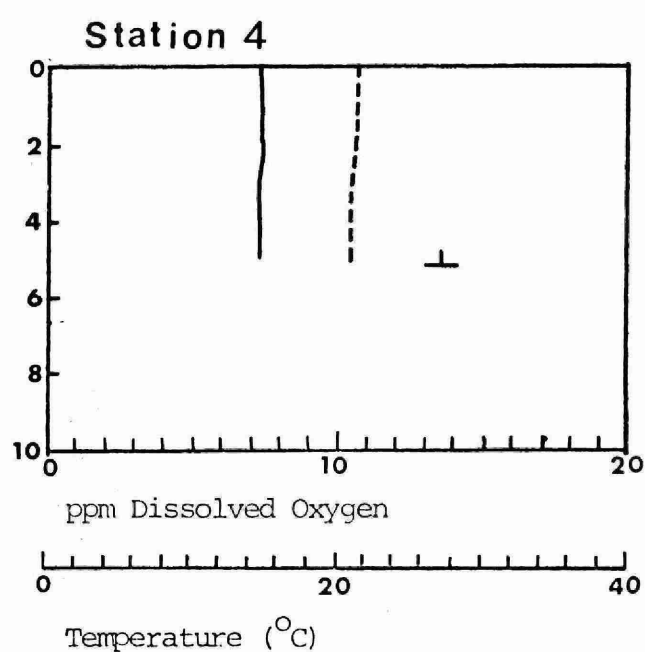
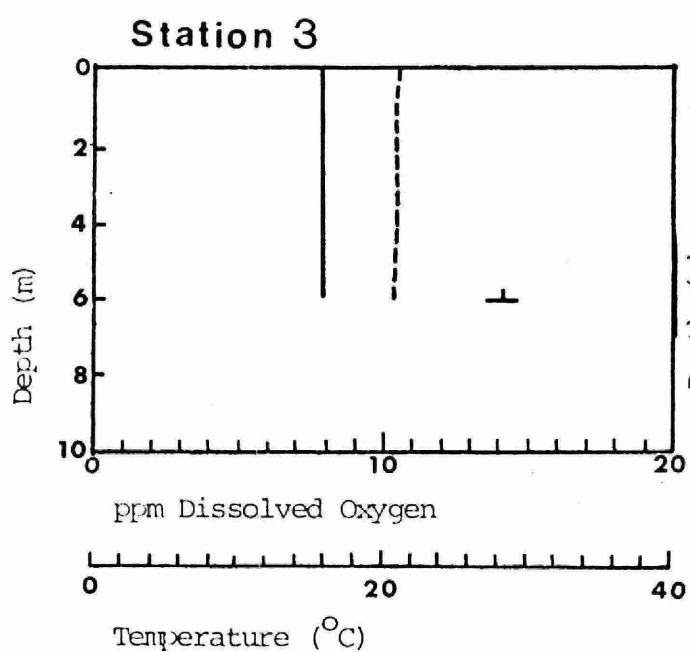
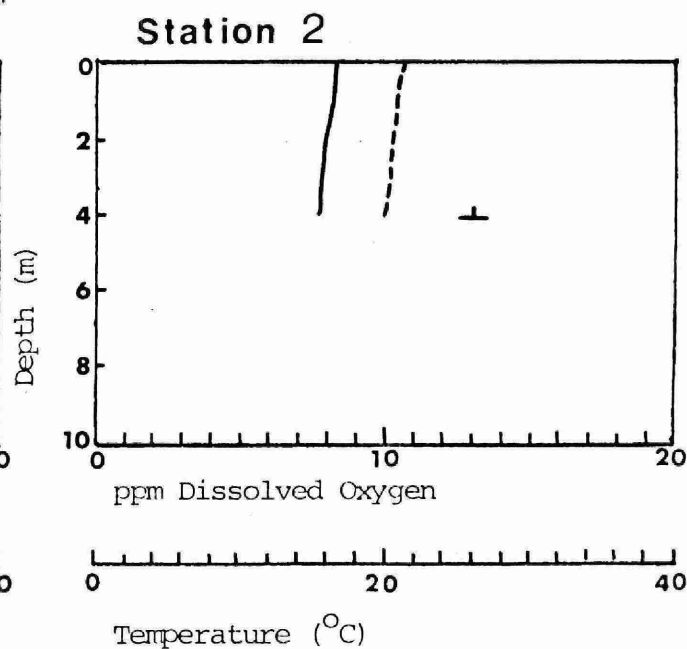
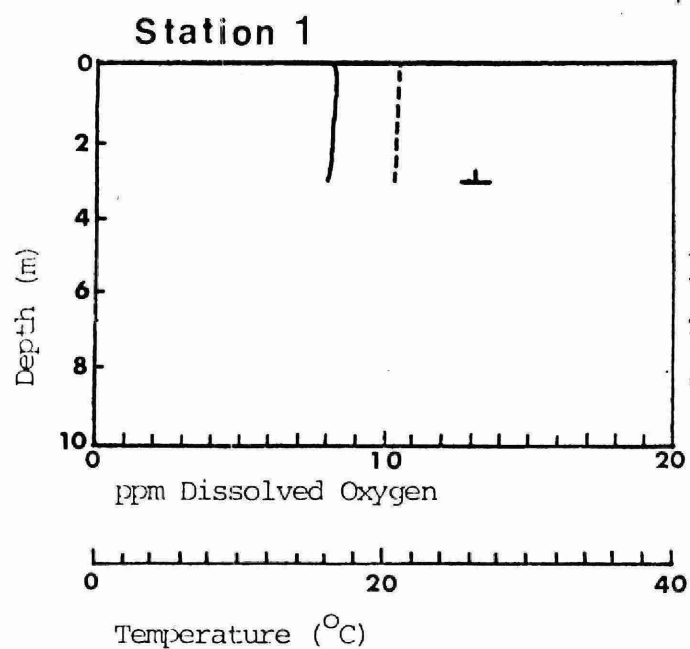


Figure A3b

Dissolved Oxygen - Temperature Profiles

Sturgeon River

August 9 1977



— Dissolved Oxygen Curve
- - - Temperature Curve
┴ Lake Bottom

Figure A4

Dissolved Oxygen - Temperature Profiles

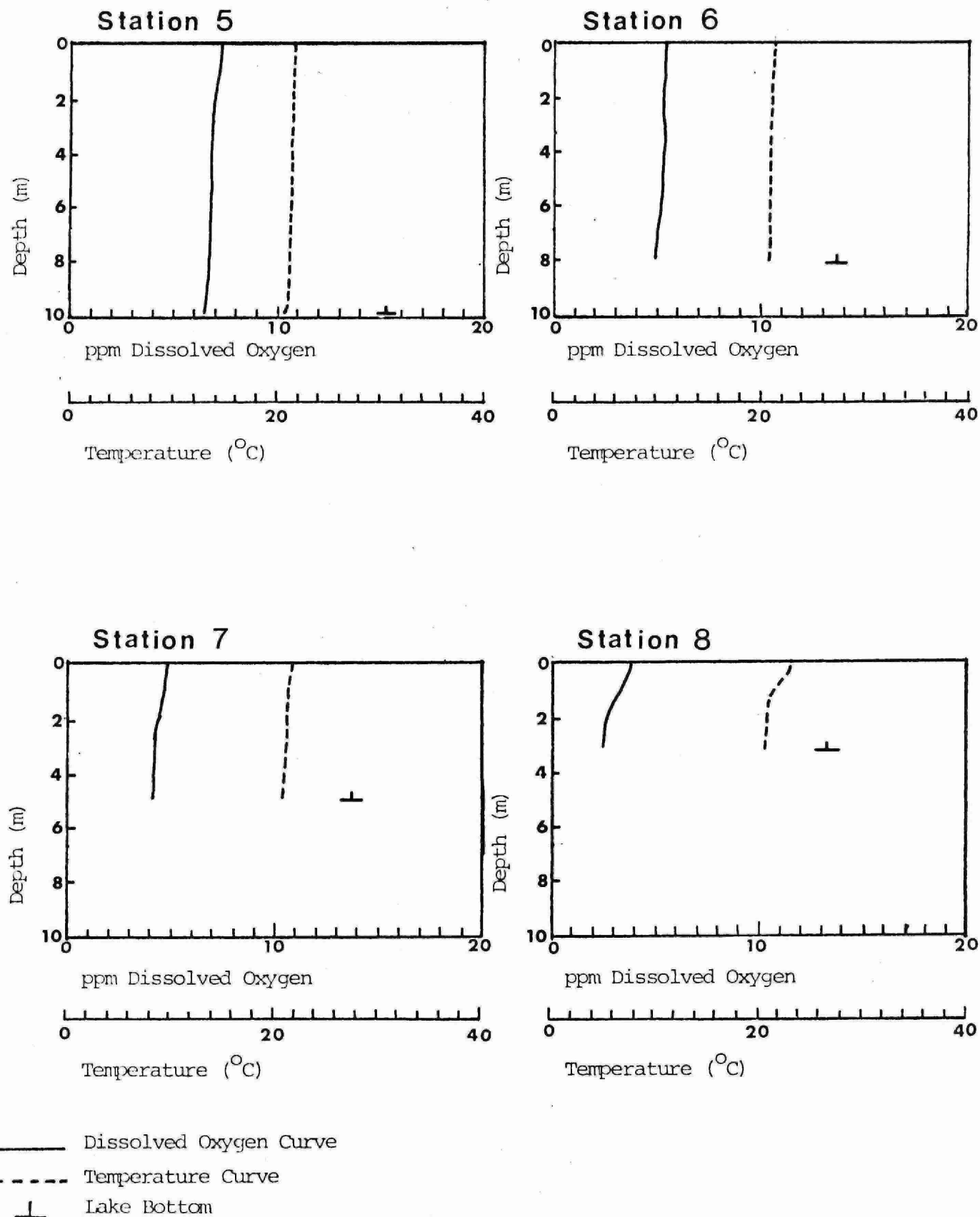
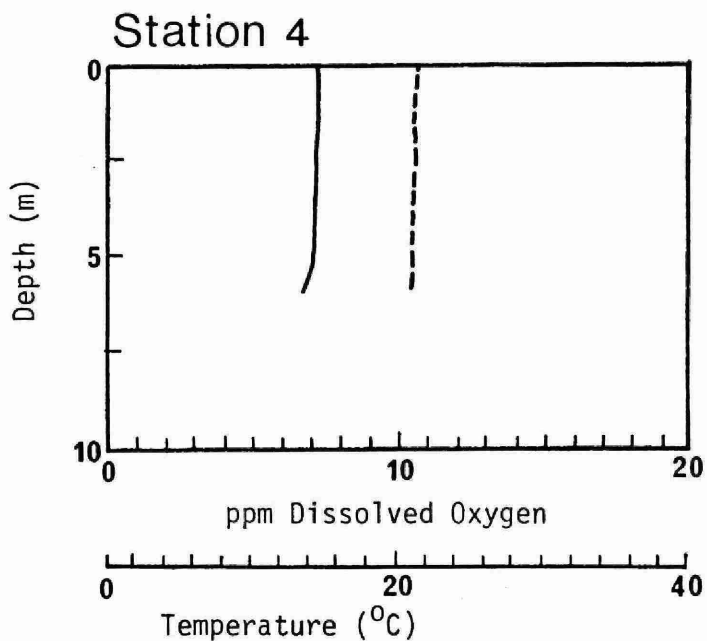
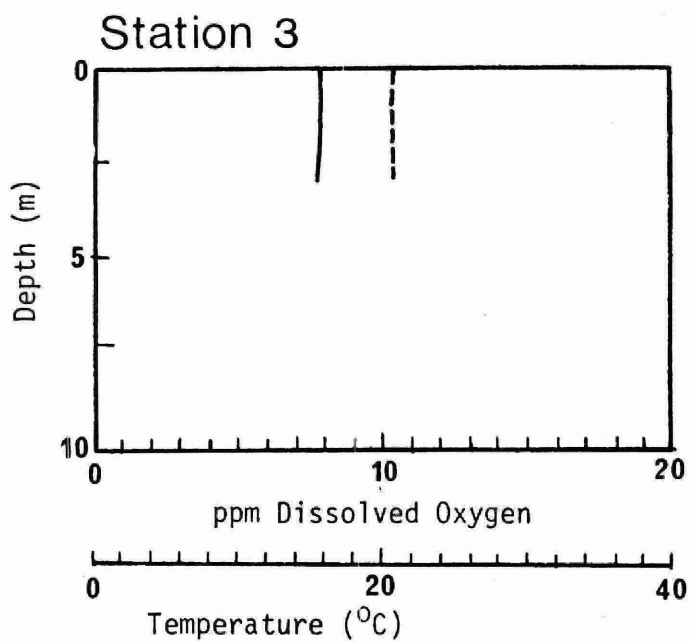
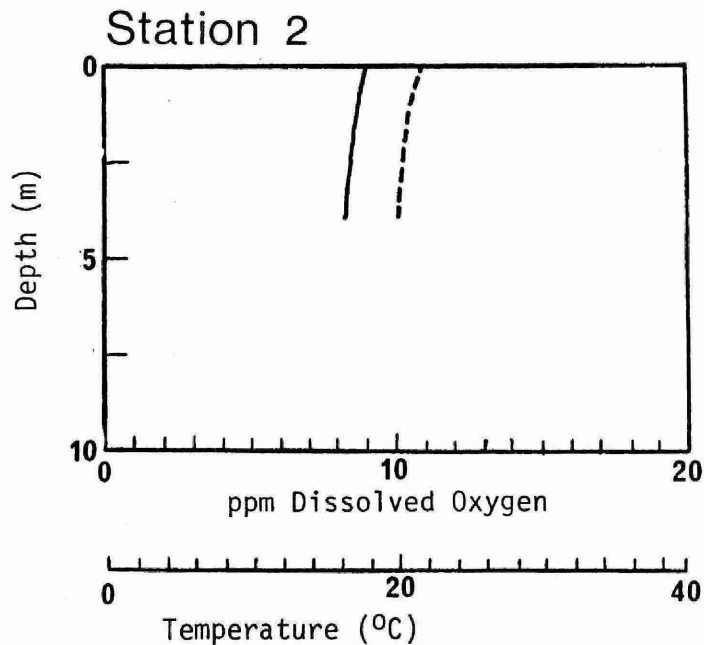
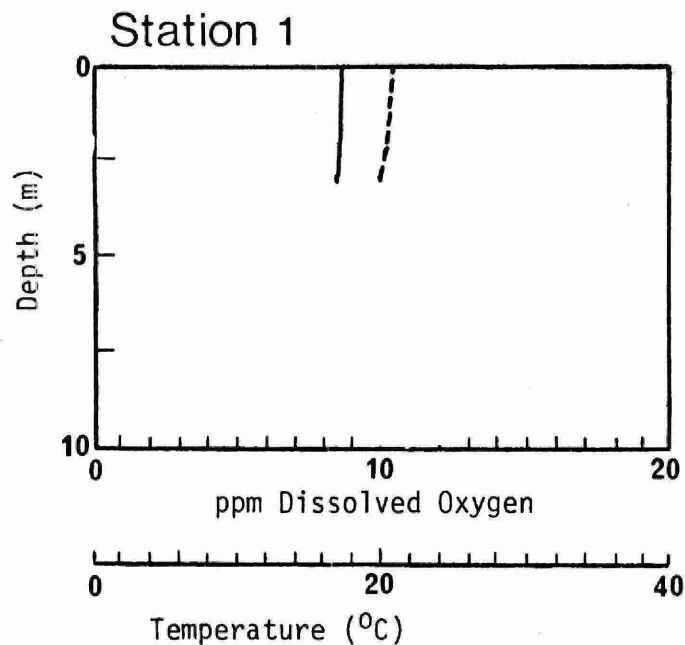


Figure A4b

Dissolved Oxygen - Temperature Profiles

Sturgeon River

August 12 1977



— Dissolved Oxygen Curve
----- Temperature Curve
| Lake Bottom

Figure A5

Dissolved Oxygen - Temperature Profiles

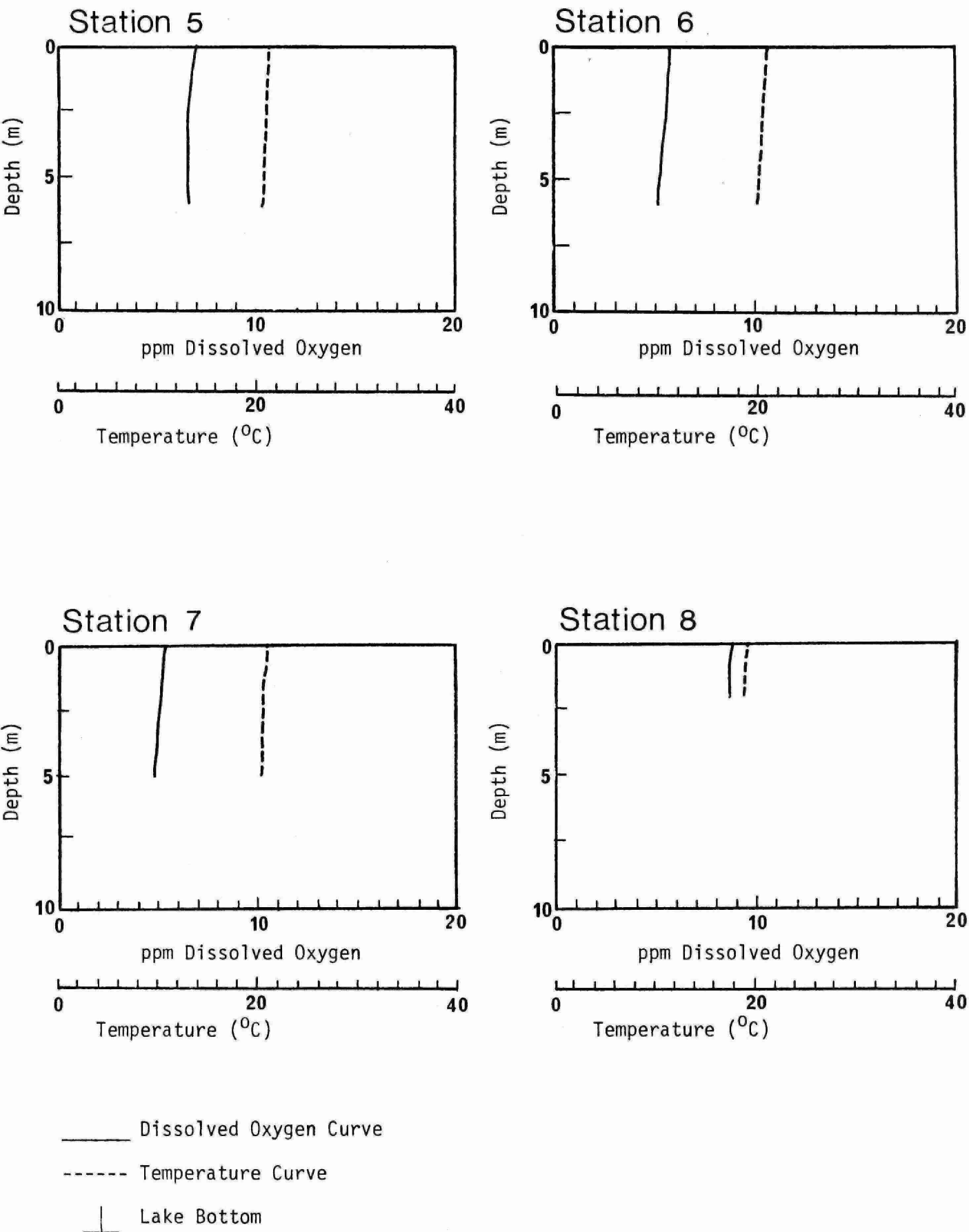


Figure A5b



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